W. B. No. 669

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 46, No. 11

NOVEMBER, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

NOVEMBER, 1918.

CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the Monthly Weather Review (e. g., January) should be in the hands of the editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

Reprints are made up without covers in the original size and pagination of the Review. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

HERBERT H. KIMBALL, Acting Editor.
CHARLES F. BROOKS, Associate Editor.

VOL. 46, No. 11.
W. B. No. 669.

NOVEMBER, 1918.

CLOSED JAN. 4, 1919.
ISSUED FEB. 4, 1919.

INTRODUCTION.

As explained in this introduction during 1914 the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW are published from time to time

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data," for the respective States, Territories, and colonies.

Since August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office.

SECTION 6.—*Bibliography.*—Recent addition to the Weather Bureau library; recent paper bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1917. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year later.

In general, appropriate officials prepare the seven sections above enumerated; but *all students of meteorology and climatology are cordially invited to contribute such additional articles as seem to be of value.*

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but are collected and published by States at selected section centers. (See cover, p. 3.)

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the REVIEW as a whole can issue from the press only within about eight weeks from the end of the month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

CORRIGENDA.

REVIEW, August, 1918:
Page 359, author's name, *for* "Wiliam A. Bentley" *read* "Wilson A. Bentley."
REVIEW, October, 1918:
Page 2 of cover, Contents, column 2, section VII,
II. Accumulated amounts of precipitation, p. "491" *should read* "494."

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING NOVEMBER, 1918.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, D. C., Dec. 30, 1918.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1918, 46:2.

The monthly means and departures from normal values in Table 1 show that direct solar radiation intensities measured slightly above normal at Madison, Wis., and slightly below normal at Washington, D. C., and Lincoln, Nebr. No measurements were obtained at Santa Fe, N. Mex., on account of a defect in the galvanometer.

On the 29th, extrapolation of the measurements obtained at Washington, Madison, and Lincoln to zero air mass gives, respectively, 1.71, 1.72, and 1.73 calories per minute per $cm.^2$ The agreement in these values is very close, especially when we take into account the vapor pressure at the three stations, as shown by the data in Table 2.

Table 3 shows a deficit of radiation at all three stations, amounting to 7 per cent of the November normal at Washington, 8 per cent at Madison, and 6 per cent at Lincoln.

Skylight polarization measurements made at Washington on 7 days give a mean of 59 per cent, and a maximum of 64 per cent on the 6th. This latter is below the average maximum for November at Washington. Measurements obtained at Madison on 9 days give a mean of 66 per cent and a maximum of 73 per cent on the 12th.

TABLE 1.—*Solar radiation intensities during November, 1918.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Nov. 1				1.08	0.98	0.88	0.80			
2		1.15	1.04	0.94	0.79					
6		1.25	1.13	1.08	1.04	0.99	0.93	0.91	0.87	
7	[*1.36]	1.29	1.21	1.12	1.05	0.99				
8			0.90	0.77	0.67					
11			1.29	1.21	1.13	1.06	0.99	0.93	0.87	
13			1.08	1.00	0.92	0.82				
14			1.03	0.93	0.81	0.73	0.66			
19				1.20	1.14	1.07	1.00	0.93	0.88	0.82
27				1.03	0.96	0.91	0.87			
29	[*1.45]			1.22	1.14	1.06	1.00	0.93	0.90	
30			1.27	1.17	1.07	0.99	0.93	0.87	0.82	
Monthly means		**1.23**	**1.12**	**1.06**	**0.98**	**0.95**	**0.90**	**0.91**	**0.87**	(0.82)
Departure from 11-year normal		**−0.12**	**−0.06**	**−0.02**	**−0.03**	**+0.05**	**+0.04**	**+0.09**	**+0.10**	**+0.11**
P. M.										
Nov. 6			1.12	0.96			0.66		0.60	
12			0.94	0.89	0.85	0.69	0.65	0.60	0.56	0.52
13			0.96	0.91	0.74	0.64	0.57	0.51	0.47	
14			1.06	1.01	0.92	0.80	0.70	0.64		
26			1.27	1.19						
27				1.05	1.00	0.95				
29			1.26	1.17	1.07				0.80	
30					1.17	1.07	1.03	0.98	0.94	
Monthly means			**1.10**	**1.03**	**0.96**	**0.83**	**0.72**	**0.68**	**0.67**	**(0.52)**
Departure from 11-year normal			**−0.07**	**−0.05**	**−0.01**	**−0.06**	**−0.09**	**−0.08**	**−0.05**	**−0.16**

* Extrapolated, and reduced to mean solar distance.

TABLE 1.—*Solar radiation intensities during November, 1918*—Continued.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	65.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Madison, Wis.										
A. M.										
Nov. 12					1.19					
13			1.39	1.32	1.25	1.19	1.12	1.06	1.02	
14				1.01	0.97	0.90	0.80	0.71	0.64	
23				1.37	1.27	1.19	1.12	1.05	0.98	0.93
25				1.33	1.25	1.17	1.10	1.01	0.97	0.90
26				1.25	1.17	1.09	1.01	0.93		
27				1.33	1.24	1.15	1.02	0.97	0.92	0.86
29	[*1.54]			1.34	1.27	1.20	1.13	1.05	1.02	0.98
Monthly means			(1.39)	**1.28**	**1.20**	**1.13**	**1.04**	**0.97**	**0.92**	**0.92**
Departure from 9-year normal			**+0.09**	**+0.06**	**+0.04**	**−0.01**	**+0.01**	**±0.00**	**+0.05**	**+0.11**
P. M.										
Nov. 8					1.09					
12				1.32						
13				1.26	1.22					
14				1.10	1.00	0.92				
23						1.17				
25				1.26	1.21					
27				1.30						
29				1.35			1.15			
Monthly means				**1.26**	**1.13**	(1.04)	(1.15)			
Departure from 9-year normal				**+0.02**	**−0.03**	**+0.01**				
Lincoln, Nebr.										
A. M.										
Nov. 1			1.32	1.23					0.92	0.86
2			1.29	1.18	1.09	1.01				
3	[*1.55]		1.36	1.26	1.17					
8			1.26	1.17						
9	[*1.61]		1.42	1.33	1.24	1.16				
11					1.17	1.09				
13	[*1.49]		1.36		1.16					
18	[*1.58]		1.42	1.30						
19	[*1.48]		1.34	1.25	1.22	1.13				
25				1.22						
29	[*1.49]			1.29	1.22		1.07			
Monthly means			**1.35**	**1.25**	**1.18**	**1.10**	(1.07)		(0.92)	(0.86)
Departure from 4-year normal			**−0.01**	**−0.05**	**−0.05**	**−0.03**	**±0.00**		**−0.07**	**−0.13**
P. M.										
Nov. 1				1.17	1.09	1.02	0.96	0.90	0.84	0.79
3			1.36	1.26	1.17	1.09	1.02		0.88	0.82
9			1.41	1.32	1.24	1.16	1.09	1.03	0.97	0.92
13			1.32	1.23	1.14	1.06	0.99	0.92	0.86	0.80
18			1.42	1.35	1.28	1.22	1.16	1.10		
19			1.35	1.26	1.18	1.10	1.04	0.98	0.92	0.87
26			1.27	1.19						
29				1.31	1.22	1.16	1.11	1.05	0.99	0.93
30			1.36	1.28	1.21	1.10				
Monthly means			**1.36**	**1.26**	**1.19**	**1.11**	**1.05**	**1.00**	**0.91**	**0.86**
Departure from 4-year normal			**−0.03**	**−0.02**	**−0.02**	**−0.01**	**−0.01**	**±0.00**	**−0.02**	**−0.05**

* Extrapolated, and reduced to mean solar distance.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*
Nov. 1	4.57	3.81	Nov. 8	8.48	6.50	Nov. 1	3.63	7.57
2	4.75	3.45	12	4.75	2.74	2	3.99	9.47
6	4.57	4.75	13	3.30	3.00	3	5.79	7.04
7	4.57	6.02	14	3.81	6.50	8	4.57	4.37
8	5.79	7.57	23	1.96	2.49	9	3.63	5.36
11	3.81	3.99	25	2.49	2.87	11	5.56	8.48
12	3.63	4.57	26	3.15	2.36	13	3.99	7.29
13	4.57	5.36	27	2.49	3.45	18	3.30	4.37
14	3.30	3.81	29	2.87	2.49	19	3.45	5.79
19	5.79	6.50				25	2.74	3.45
26	2.87	3.63				29	1.96	3.63
27	2.87	3.99				30	2.16	4.57
29	6.02	3.81						
30	3.30	2.49						

TABLE 3.—*Daily totals and departures of solar and sky radiation during November, 1918.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Nov. 1	183	277	354	−75	84	97	−75	84	97
2	217	152	332	−39	−39	78	−114	45	175
3	308	51	338	54	−137	87	−60	−92	262
4	217	196	235	−35	10	−13	−95	−82	249
5	203	214	47	−47	30	−198	−142	−52	51
6	304	208	78	57	27	−165	−85	−25	−114
7	290	60	44	47	−119	−196	−38	−144	−310
8	242	160	306	2	−16	69	−36	−160	−241
9	72	57	353	−164	−117	118	−200	−277	−123
10	284	213	292	51	42	60	−149	−235	−63
11	315	226	309	86	57	79	−63	−178	16
12	284	241	316	58	75	88	−5	−103	104
13	258	242	275	36	78	49	31	−25	153
14	254	207	160	35	46	−64	66	21	89
15	232	55	49	16	−103	−173	82	−82	−84
16	156	23	52	−57	−133	−167	25	−215	−251
17	32	36	48	−178	−117	−169	−153	−332	−420
18	127	30	320	−80	−121	105	−233	−453	−315
19	192	45	301	−12	−103	88	−245	−556	−227
20	115	53	58	−86	−93	−153	−331	−649	−380
Decade departure							**−182**	**−414**	**−317**
21	86	39	46	−112	−104	−163	−443	−753	−543
22	131	180	91	−64	39	−116	−507	−714	−659
23	191	212	131	−1	73	−74	−508	−641	−733
24	165	220	252	−25	83	49	−533	−558	−684
25	208	202	256	21	67	55	−512	−491	−629
26	230	197	277	46	63	78	−466	−428	−551
27	235	199	88	53	66	−109	−413	−362	−660
28	36	11	291	−144	−121	96	−557	−483	−564
29	234	199	275	57	68	82	−500	−415	−482
30	238	190	258	63	60	67	−437	−355	−415
Decade departure							**−106**	**+294**	**−35**
Excess or deficiency since first of year — gr.-cal.							**−3211**	**+154**	**−550**
Excess or deficiency since first of year — per cent.							**−2.6**	**+0.1**	**−0.4**

SOME CHARACTERISTICS OF THE MARVIN PYRHELIOMETER.

By PAUL D. FOOTE, Associate Physicist, Bureau of Standards.

[Scientific Papers of the Bureau of Standards, No. 323.]

(Issued Washington, June 28, 1918.)

[Abstract.]

This pyrheliometer is dynamic in type, in that it is necessary to consider the rate at which the receiver gains heat when exposed to radiation and the rate at which the receiver loses heat when shaded from radiation.

The essential feature of the instrument is the receiver. In the form used in the present work it consisted of a silver disk about 4.5 cm. in diameter and 0.3 cm. thick, in an annular space inside of which is carefully mounted with the best possible thermal contact a noninductive spirally wound coil of No. 35 silk insulated nickel wire in the form of a 3-lead resistance thermometer, having a total resistance of from 20 to 25 ohms. The coil serves both as the thermometer and as the heater for the purpose of an electrical calibration, the rise in temperature of the thermometer being observed when a known amount of electrical energy is dissipated in the coil. The receiver is mounted within a metal shell, which is incased by a wooden shell in order to reduce local temperature variations to a minimum, and the type of suspension of the receiver is such that thermal losses by conduction are negligible. Before the front face of the receiver a limiting diaphragm is placed, and leading from this, through a hole in the metal and wooden shells, is a diaphragmed and blackened tube which serves the purpose of limiting the cone of rays to a convenient solid angle greater than that subtended by the sun. The end of the tube carries a double-walled aluminum shutter, operated by a magnetic release controlled by a chronograph, which may be so set as to open or close the shutter at any desired instant. For solar work the instrument is mounted as an equatorial telescope and is driven by clockwork, so that the surface of the receiver is always presented normally to the sun.

The determination of the relation between the temperature of the thermometer and its resistance requires an independent experiment in which the receiver is removed from the pyrheliometer and mounted in a constant temperature bath, the temperature of which may be varied over the range required. The temperature relation so found may be accurately expressed by a parabolic equation, and for silver block No. III, which was employed in the present investigation, $R=19.521+0.08394t+0.00010127t^2$, where t is the temperature centigrade. These data were obtained by Prof. H. H. Kimball, of the United States Weather Bureau.

The electrical calibration was made by subjecting the nickel coil of the thermometer to a measured current and observing the change in temperature indicated by the thermometer. The radiometric calibration was made in a similar manner except that the heat was supplied by radiation from an outside source. The source employed was a Lummer-Kurlbaum black body, or a black body of similar type, electrically heated, with a compensating winding to reduce the temperature gradient and to approximate temperature uniformity. The temperature of the inner inclosure, from which the radiation was taken, was measured by standard platinum, platinum-rhodium thermocouples, accurately calibrated in terms of the melting points of zinc (419.4°), antimony (630.5°), and copper (1083°). A water-cooled diaphragm was mounted directly in front of the opening to the furnace. This diaphragm acts as the effective source of radiation. The equation of rate of energy transfer from the furnace to the pyrheliometer receiver is as follows when R is large compared with $\sqrt{A_1}$ and $\sqrt{A_2}$.

$$J=\frac{\sigma}{\pi}\left(T^4-T_0^4\right)\frac{A_1A_2}{R^2}$$

where J = energy transferred per unit time from furnace to receiver.

A_1 = area of water cooled diaphragm in front of furnace.

A_2 = area of inmost or effective diaphragm in the pyrheliometer.

T = absolute temperature of furnace.

T_0 = absolute temperature of pyrheliometer receiver and surroundings.

σ = the Stefan-Boltzmann coefficient of radiation.

R = distance from A_1 to A_2.

The quantity T_0^4 is negligible, for the present work, in comparison with T^4.

In the case of electrical calibration,

$$J = i^2 r,$$

where i is the amperage of the heating current, and r is the resistance of the thermometer.

The object of the calibration of the pyrheliometer is to evaluate

$$F' = \frac{\Delta J}{\Delta T}$$

where ΔJ is the heat applied to the pyrheliometric receiver per minute per unit of surface area, and ΔT is the measured change in temperature of the coils of the receiver per minute.

Having determined F', for solar radiation measurements we have the equation $\Delta J = F \Delta T$. $(F = F' + Cor.)$

On account of the lag effect the observed value of $\Delta T / \Delta t$ (t = time) in the interval 0 to 10 seconds after opening or closing the shutter was found to be too small in the case of radiometric heating and too large in the case of electrical heating. It was therefore omitted from the results, and to reduce temperature changes measured in 50-second intervals to 60-second intervals the factor 1.217 was found necessary. This factor is the same for radiometric as for electrical heating, and its value agrees with that previously determined by the Weather Bureau for electrical heating.

The following table summarizes the results of various experiments with Marvin silver block No. 3. Each experiment represents a series of observations which in most cases extended over an hour. The first column gives the total energy supplied to the disk during each minute of heating. It is clearly shown that the calibration constant F', determined electrically, is independent of the amount of energy supplied although this latter extended over a considerable range.

TABLE 1.—*Final calibration of Marvin silver block No. 3.*

ELECTRICAL CALIBRATION.

Cal./minute.	F'.	Cal./minute.	F'.
0.2704	[1] 2.104	0.2755	[2] 2.141
0.2713	[1] 2.176	0.4925	[2] 2.116
0.4871	[1] 2.089	0.4945	[2] 2.099
0.7659	[1] 2.098	0.7772	[2] 2.089
0.7697	[1] 2.100		2.111
3.136	[1] 2.100		
7.211	[1] 2.098		
13.181	[1] 2.115		
21.321	[1] 2.101		
	[1] 2.109		
	2.110		

[1] Data taken in November, 1915. [2] Supposedly more accurate data taken March, 1916.

RADIOMETRIC CALIBRATION.

Cal./minute.	F'.	Temperature of furnace.	Distance between limiting diaphragms
		Degrees abs.	*Cm.*
0.1983	2.200	1,601	94.0
0.3351	2.173	1,602	72.4
0.4631	2.186	1,731	71.9
0.3138	2.214	1,649	79.2
	2.200		

A previous electrical calibration by the Weather Bureau gave for F' the value 2.1308.

The author then applies certain obviously necessary corrections to these results, the most important being a correction of +1.2 per cent to the electrically determined factor on account of incomplete absorption of radiation by the blackened surface of the receiver, and obtains for his mean values

$$F = 2.135 \text{ (electrical calibration).}$$

$$F = 2.200 \text{ (radiometric calibration).}$$

He gives reasons for considering the radiometric method the more accurate of the two, and then employs the factor $F = 2.200$ to reduce measurements of solar radiation with Marvin silver block No. 3, made synchronously with measurements by Smithsonian silver block pyrheliometer No. 1. This last instrument was standardized through the Smithsonian Absolute pyrheliometer.

The results are given in Table 2.

TABLE 2.—*Data on solar observations.*

Date.	Marvin pyrheliometer.	Smithsonian pyrheliometer.	Marvin/ Smithsonian.
	Cal./cm² min.	*Cal./cm² min.*	
Nov. 10, 1915	1.162	1.189	0.978
Do	1.352	1.388	.974
Do	1.262	1.302	.971
Nov. 26, 1915	1.160	1.169	.991
Nov. 27, 1915	1.230	1.253	.980
Mean			.98

The difference, 2 per cent, is considered to be within the probable error of F, and the results may be considered confirmatory of the accuracy of the Smithsonian standard.

The presentation of the theory of the pyrheliometer while based on recognized fundamental equations, has led to original forms of heating and cooling equations especially adapted to the case under consideration.

SUMMARY.

For the first time, it is believed, a pyrheliometer has been calibrated by two methods, the usual electrical method and a radiometric method. In the radiometric method a known quantity of radiation from a black body was allowed to fall upon the pyrheliometer receiver in exactly the same manner as when employed for solar measurements. The calibrations by the two methods agreed within limits of experimental error, if the Stefan-Boltzmann constant were chosen as $\sigma = 5.7 \times 10^{12}$ watts cm.$^{-2}$ deg.$^{-4}$, the latest and most accurate determination of this constant of total radiation. Or conversely, the constant has been observed as 5.7×10^{-12} within an accuracy of possibly 5 per cent.

The behavior of the Marvin pyrheliometer has been carefully investigated. A lag, part of which is due to the galvanometer of the bridge, has been found to exist, and, for the silver disk No. 3, was experimentally shown to be less than 2 seconds. Both theoretically and experimentally it was shown that the effect of this lag is negligible after 5 to 10 seconds. The cooling and heating of the receiver follows Newton's law of cooling.

In order to completely eliminate errors due to a lag effect, readings should be made at 10 seconds and 60 seconds following the beginning of a heating or cooling. The factor for converting readings of temperature or resistance change over this 50-second interval to corresponding changes over a complete 60-second period is 1.217. This factor is the same for both electrical and radiometric heating and was determined with an accuracy of 0.1 per cent. There is no advantage in making the periods of heating and cooling 120 seconds in duration. Periods of 60 seconds are sufficient. The method of blackening the receiver is of great importance. The best method used for blackening is that used by Coblentz. The calibration constant F appears independent of the rate at which energy is supplied to the receiver, at least for an electrical calibration.—*H. H. K.*

Halo phenomena observed during November, 1918.

[By Willis Ray Gregg, Meteorologist.]

Station.	Altitude.	Latitude.		Longitude.		Date.	Form observed.	Time of— Beginning.	Time of— Ending.	Theodolite readings. Time.	Radius inside.	Radius outside.	Length of arc.	Distance from sun or moon.	Altitude of sun or moon.
	m.	°	′	°	′						°	°	°	°	°
Broken Arrow, Okla.*	233	36	02	95	49	None.									
Canton, N. Y.	137	44	36	75	10	None.									
Cincinnati, Ohio	191	39	06	84	30	7	Solar halo, 22°	9:30 a. m.	12:30 p. m.						
						7	Parhelion, 22°, right	11:20 a. m.	11:50 a. m.						
						7	Parhelion, 22°, left	11:20 a. m.	11:50 a. m.						
						7	Upper tangent arc	11:20 a. m.	12:30 p. m.						
						24	Lunar halo, 22°	5:25 a. m.	5:45 a. m.						
						24	Solar halo, 22°	12:15 p. m.	12:25 p. m.						
Dayton, Ohio	274	39	46	84	10	7	Solar halo, 22°	11:00 a. m.	12:30 p. m.						
						11	Solar halo, 22°	8:21 a. m.	10:00 a. m.						
						16	Lunar halo, 22°	6:05 p. m.	7:08 p. m.						
						25	Solar halo, 22°	8:30 a. m.	8:50 a. m.						
Droxel, Nebr.*	396	41	20	96	16	2	Solar halo, 22°	12:00 m.	12:40 p. m.	12:22 p. m.	22	23	270		34
						10	Solar halo, 22°	10:30 a. m.	11:00 a. m.	10:50 a. m.	22	23	160		28
						11	Lunar halo, 22°	6:25 p. m.	10:41 p. m.	6:55 p. m.	22	23	360		38
						12	Solar halo, 22°	8:30 a. m.	9:10 a. m.	9:05 a. m.	22	23	120		16
Ellendale, N. Dak.*	444	45	59	98	34	14	Lunar halo, 22°	6:55 p. m.	8:35 p. m.						
Groesbeck, Tex.*	141	31	30	96	28	20	Solar halo, 22°	8:30 a. m.	8:48 a. m.	8:44 a. m.	22	24	360		20
						29	Parhelion, 22°, right	7:54 a. m.	8:00 a. m.	7:56 a. m.			2	22	8.5
Leesburg, Ga.*	85	31	47	84	14	15	Solar halo, 22°	11:40 a. m.	4:00 p. m.	3:50 p. m.			180		
						15	Upper tangent arc	3:35 p. m.	4:00 p. m.	3:50 p. m.			10		
						15	Lunar halo, 22°	5:20 p. m.	D. N.				360		
						20	Solar halo, 22°	1:00 p. m.	2:18 p. m.				360		
						21	Solar halo, 22°	1:37 p. m.	3:15 p. m.	2:15 p. m.			160		
Madison, Wis.	297	43	05	89	23	5	Solar halo, 22°	11:00 a. m.							
						7	Solar halo, 22°	7:20 a. m.	7:40 a. m.						
						10	Solar halo, 22°	11:00 a. m.	11:50 a. m.						
						14	Lunar halo, 22°	7:45 p. m.	9:00 p. m.						
Nashville, Tenn.	166	36	10	86	47	7	Solar halo, 22°	11:30 a. m.	2:00 p. m.						
						14	Lunar halo, 22°	6:00 p. m.	8:00 p. m.						
Royal Center, Ind.*	225	40	53	86	29	12	Solar halo, 22°	11:30 a. m.	12:25 p. m.	12:10 p. m.			360	23.8	31
						14	Lunar halo, 22°	7:30 p. m.	D. N.				360		
						15	Solar halo, 22°	7:45 a. m.	8:05 a. m.	7:50 a. m.			180		11
						16	Lunar halo, 22°	6:25 p. m.	6:45 p. m.				360		

Station.	Date.	Colors.†	Degree of brightness.	Clouds. Amount.	Clouds. Kind.	Clouds. Direction.	Station pressure.	Precipitation. Last previous ended.	Precipitation. First subsequent began.
Broken Arrow, Okla.*	None.								
Canton, N. Y.	None.								
Cincinnati, Ohio	7	R. O. Y. G. B. V.	Bright	10	Ci. St.	nw	Stationary	2:00 a. m., 1st	10:55 a. m., 8th.
	7		Dim						
	7		Dim						
	7		Dim						
	24		Dim	10	A. St.	w	Stationary	3:20 p. m., 20th	1:30 a. m., 28th.
	24		Dim	8	A. St.	w	Falling		
Dayton, Ohio	7		Dim	8	Ci. St.	sw	Falling	3:50 p. m., 31st	11:53 a. m., 8th.
	11		Dim	7	Ci. St.	nw	Stationary	7:55 a. m., 9th	6:05 a. m., 16th.
	16		Dim	10	Ci. St.	sw	Falling	1:05 p. m., 16th	9:10 p. m., 16th.
	25		Dim	5	Ci. St.		Rising	5:20 p. m., 20th	D. N. a., 28th.
Drexel, Nebr.*	2	R. O. G. G. B. V.	Brilliant	6	Ci. St.	w	Falling	D. N. p., 30th	5:00 a. m., 6th.
	10	R.	Dim	7	Ci. St.	w	Stationary	5:00 p. m., 7th	4:15 p. m., 14th.
	11		Dim	4	Ci. St.	w	Rising	5:00 p. m., 7th	4:15 p. m., 14th.
	12	R. O. Y. G. B.	Dim	2	Ci. St.	wnw	Rising	5:00 p. m., 7th	4:15 p. m., 14th.
Ellendale, N. Dak.*	14		Brilliant	6	Ci. St.	w	Stationary	D. N. p., 8th	9:10 a. m., 15th.
	20		Dim	8	Ci. St.	w	Stationary	11:10 a. m., 15th	12:40 p. m., 20th.
Groesbeck, Tex.*	29	R. O. Y. G. B. I. V.	Brilliant	2	A. St.	ssw	Rising	7:15 p. m., 27th	9:05 a. m., 16th.
Leesburg, Ga.*	15	R.	Dim	8 2	Ci. A. St.	w w	Falling Falling	5:04 p. m., 30th	
	15		Bright	10	Ci.	nw	Rising		
	20		Dim	7	Ci. St.	sw	Stationary	2:15 p. m., 17th	2:00 a. m., 22d.
	21		Dim	8	Ci. St.	wsw	Stationary	2:15 p. m., 17th	2:00 a. m., 22d.
Madison, Wis.	5		Dim	8	Ci. St.	w	Stationary	7:10 a. m., 3d	10:35 a. m., 7th.
	7	R.	Dim	2 8	Ci. St. A. Cu.	w sw	 Stationary	 7:10 a. m., 3d	 10:35 a. m., 7th.
	10	R.	Bright	8	Ci. St.	w	Stationary	12:30 p. m., 9th	8:27 a. m., 15th.
	14		Bright	10	Ci. St.	w	Stationary	12:30 p. m., 9th	8:27 a. m., 15th.
Nashville, Tenn.	7	R.	Dim	9	Ci. St.	nw	Falling	4:00 p. m., 31st	1:00 a. m., 9th.
	14		Dim	4	A. St.	sw	Stationary	10:50 a. m., 9th	D. N. a., 16th.
Royal Center, Ind.*	12	R.	Dim	7	Ci. St.	w	Falling	D. N. a., 9th	D. N. a., 16th.
	14	R.	Bright	7	Ci. St.	w	Rising	D. N. a., 9th	D. N. a., 16th.
	15	R.	Dim	6 4	Ci. St. A. St.	sw sw	 Rising	 D. N. a., 9th	D. N. a., 16th.
	16	R.	Dim	5 3	Ci. St. A. Cu.	w s	 Falling	 2:00 p. m., 16th	D. N. a., 17th.

* Aerological station.

† Beginning with part nearest sun or moon. R, red; O, orange; etc.

SECTION II.—GENERAL METEOROLOGY.

THE DUSTFALLS OF MARCH, 1918.

By ALEXANDER NEWTON WINCHELL, Professor of Mineralogy and Petrology, University of Wisconsin, and ERIC REXFORD MILLER, Meteorologist, U. S. Weather Bureau.

[Dated: Madison, Wis., Dec. 24, 1918.]

Light falls of dust occur so frequently as to attract no attention, except from housewives; heavier falls are rare and pass away so quickly that quantitative measurements of them are not often made. Unusually heavy dustfalls occurred in March, 1918, in the Central and Eastern States. At Madison the time of beginning and end of the fall and the density of the fall were accurately determined, and the dust has been examined by investigators familiar with the physical, mineralogical, zoological, and botanical problems presented by it. Atmospheric dust has been discussed in its general relations by Free (1) and by Humphreys (3) (4), so that this paper will be confined to the presentation of the data collected relative to the dustfalls of March, 1918.

Origin of the dust.—Notwithstanding the impression of some of the observers of the dustfall, that the dust was of local origin, the following circumstances point to the arid Southwest as the source from which it came:

(*a*) High winds, dust storms, and sand storms occurred from Arizona eastward to the Mississippi River. Part of the area was especially liable to the blowing of soil on account of an unusually prolonged drought.

(*b*) The Northern States, including most of those in which the deposit of dust was observed, were covered with snow, as shown in figures 1 and 3 (shaded areas), where the limits of snow on the ground on March 4 and 11 are reproduced from the Snow and Ice Bulletins of the Weather Bureau.

(*c*) The Southeastern and Central States had no protecting cover of snow, but the wetness of the soil and the cover of vegetation seems to have kept down the blowing of soil. Inquiries addressed to the section directors of the climatological services of Illinois, Indiana, and Ohio brought the response that, while high winds accompanied the March storms, no reports of blowing of soil had come to their notice.

(*d*) Microscopic study of the dust collected at Madison, Wis., and at Oberlin, Ohio, reveals several facts having an important bearing on its origin. First, it is well sorted and very fine. Both of these facts indicate that it has been carried a long distance in the air. Next, the dust contains abundant limonite and hematite, although kaolin is not abundant and the feldspar is entirely unaltered. These facts indicate that the dust is a product of physical disintegration and not of chemical decomposition, therefore that it is derived from a region of very arid climate and not from any part of the Mississippi Valley. Again, the dust is dominantly composed of feldspar and quartz, with very small amounts of other constituents. Therefore it is derived from a region of siliceous feldspathic rocks, either granite or arkose, or a gneiss of similar composition, like the Rocky Mountain region. It is not derived from a region of limestone, sandstone, mica schist, or basic igneous rocks. It con-

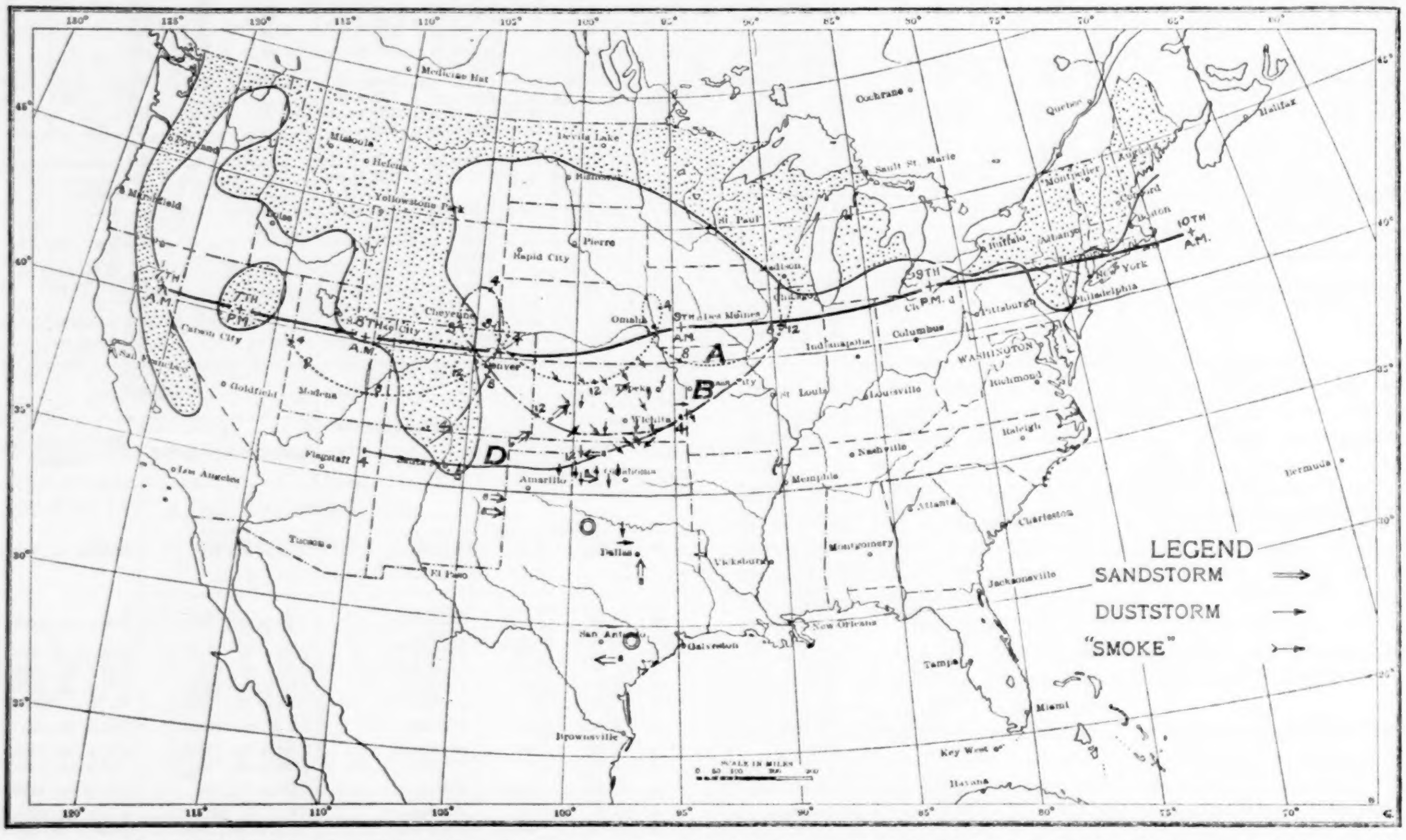

FIG. 1.—Dust of March 8 and 9, 1918: Cyclone track, wind paths, snow-covered area (shaded), 8 p. m., March 4, and dust storms and sand storms reported by cooperative observers of the Weather Bureau in Arizona, New Mexico, Texas, Oklahoma, Kansas, and Missouri on March 8 (marked "8") and March 9, 1918.

tains far too little kaolin, and its feldspar is too fresh to be derived from any ordinary shale or argillite. Therefore it is not derived from any part of the Mississippi Valley east of the Rocky Mountains or south of Minnesota. Finally, the proportion of organic materials in the dust (about 5 per cent) is so much smaller than the proportion reported in European dustfalls as to indicate a barren region as the place of origin.

Translocating agents.—Three well-developed cyclones crossed the continent in March, 1918; the tracks of the centers of these, numbered III, IV, and V, are shown on Chart XLVI-24, "Tracks of centers of low areas, March, 1918," in the MONTHLY WEATHER REVIEW, March, 1918. No. III appeared on the California coast on the evening of the 6th and passed off the field of the weather map in the vicinity of Newfoundland on the morning of the 11th (see fig. 1). No. IV crossed between the morning of the 10th and the night of the 13th (see fig. 2); No. V, between the morning of the 11th and the night of the 15th (see fig. 3). III and V followed nearly the same path eastward from Utah along the parallel of 40° to Lake Erie, thence east-northeast to Newfoundland. IV entered over northern California, but followed a more northerly course.

Cyclone III was characterized by unusually high winds. Of the list of winds of 50 miles per hour or higher tabulated in the MONTHLY WEATHER REVIEW, March, 1918, page 155, nearly one-half were due to this storm. The following table gives the higher velocities, for 5 minutes, attained in successive 12-hour intervals between the simultaneous observations at 8 a. m. and 8 p. m., 75th Meridian Time:

March 7-8, p. m. to a. m., Modena, Utah, 30 miles per hour.
March 8, a. m. to p. m., Modena, 52; Flagstaff, Ariz., 48.
March 8-9, p. m. to a. m., Oklahoma, 48; Denver, 44; Wichita, 44.
March 9, a. m. to p. m., St. Louis, 74; Wichita, 65.
March 9-10, p. m. to a. m., Washington, 40; Pittsburgh, 40.
March 10, a. m. to p. m., New York, 87.

The area of deflation (blowing away of fine dust) in Arizona, New Mexico, Texas, Oklahoma, Kansas, and Missouri, due to storm III is shown in figure 1, and those due to LOWS IV and V in figures 2 and 3. These reports of dust storms and sand storms on March 8, 9, 10, 11, 12, and 13 have been charted for us from the reports of cooperative observers of the Weather Bureau through the kindness of Mr. Herbert Lyman, of the MONTHLY WEATHER REVIEW staff.

Trajectory of the dust cloud.—The advance of a dust cloud has been traced in some of the instances quoted by Free (**1**), and in the case of the volcanic dust from Katmai by Kimball (**6**). We have not been able to imitate this procedure, for the reason that we have so far obtained no definite observations of atmospheric haze, except from observers in Ohio on March 12. We have, therefore, tried to conjecture the probable path on the basis of the following considerations:

(1) The winds near the ground can be eliminated at once, first because the dust was brought down at Madison by sleet, which from its form is known to have come from an upper, warmer stratum, and to have frozen in falling through a lower, colder stratum; and second, because the lower wind, traced back along its course is found to have come from the northeast, with only moderate velocity, over snow-covered ground and the waters of Lake Michigan, while it was under the influence of the storm, so that it had neither the strength nor the opportunity to pick up dust.

(2) We have attempted to compute graphically the trajectory of the upper, dust-bearing wind on the assump-

FIG. 2.—Dust of March 10 and 11, 1918: Cyclone track and dust storms reported by cooperative observers of the Weather Bureau in Arizona, New Mexico, Texas, Oklahoma, Kansas, and Missouri, March 10 (marked "10") and March 11, 1918.

tion that it was a "gradient wind," and that the cyclone was of the "revolving fluid" type. The direction of a gradient wind is the direction of the isobar, its speed is determined by the pressure gradient, density of the air, deflective effect of the earth's rotation and centrifugal force due to a curved path. For our purpose this speed was determined by using the revised monogram recently published by Humphreys (**5**). Shaw (**8**) defines revolving fluid as "a column or disk of air which spins about a vertical axis and at the same time travels with a velocity of translation which is common to every part of the column or disk, and which therefore does not alter the relative motion of the air about its axis."

The gradient velocity was compounded with the average hourly drift of the storm. Working backward from Madison from the points determined by the observed beginning and ending of the dustfall, about 11 a. m. and velocity by 4 a. m. March 9. This example indicates that the calculated gradient velocity is a maximum condition, with respect to both northerly and easterly components of motion. It is scarcely probable that the true origin was as far west or as far north as the line of gradient velocity. On the other hand it is not likely that the place of origin of the dust was east of the 95th Meridian, because the strong convectional currents of daytime did not occur east of the Plains until the afternoon of the 9th, when the storm was passing over the Mississippi Valley. It was then too late for the fast, moving gradient wind itself must have reached the Mississippi River by 7 a. m. of the 9th in order to arrive at Madison by 11 a. m. That the nighttime ascent is weak, even in the center of the cyclone is strongly suggested by the daytime widening and nighttime narrowing of the belt of rain. The absence of rainfall about the center of the cyclone from midnight, March

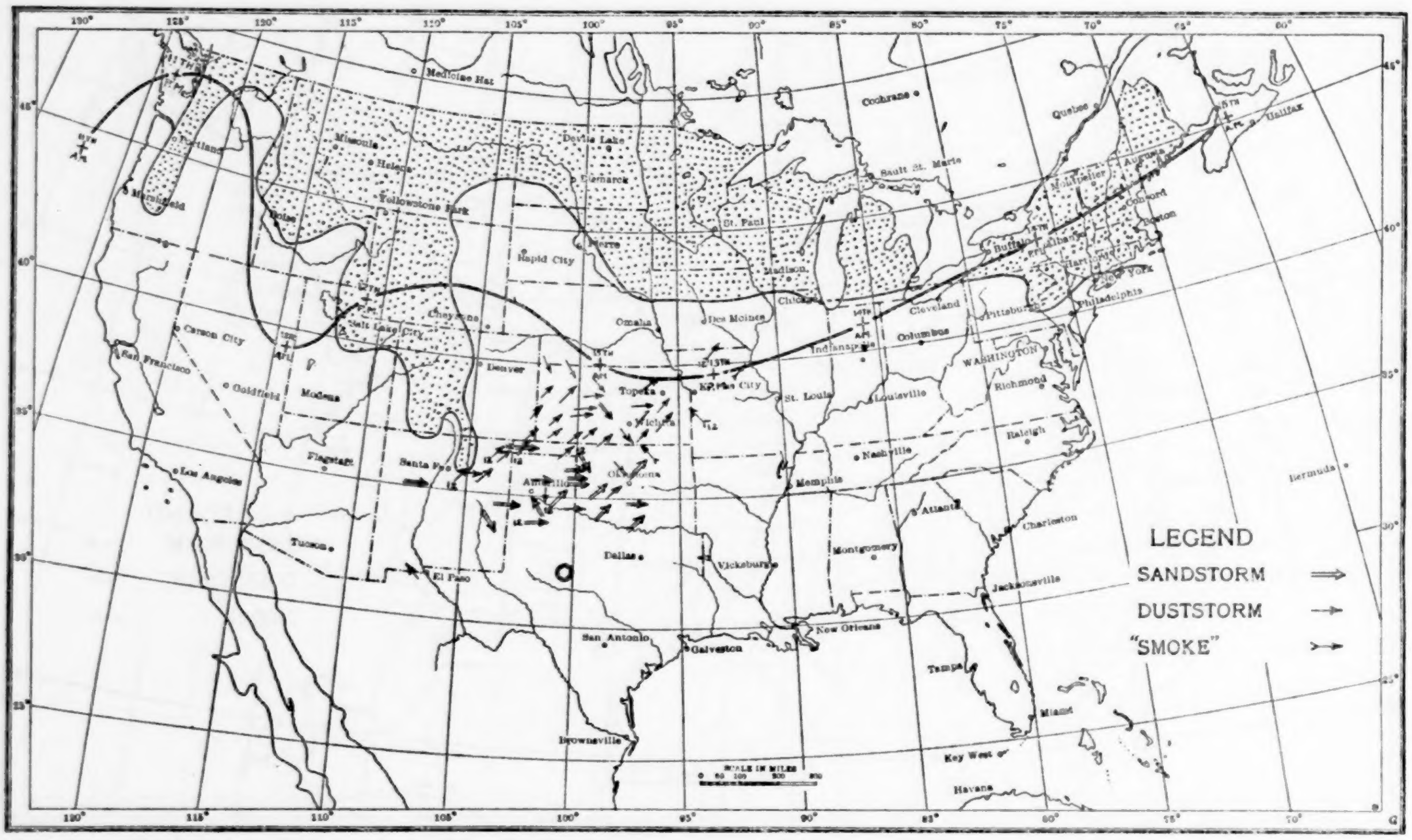

FIG. 3.—Dust of March 12 and 13, 1918: Cyclone track, snow-covered area (shaded), 8 p. m., March 11, 1918, and dust storms and sand storms reported by cooperative observers of the Weather Bureau in Arizona, New Mexico, Texas, Oklahoma, Kansas, and Missouri, March 12 (marked, "12") and March 13, 1918.

3 p. m., March 9, the trajectories marked A and B in figure 1 were obtained for the dust-bearing winds. These trajectories, and especially their loops, resemble the actual trajectories obtained by Shaw (**9**) from the study of surface air currents.

The dust must have been carried up from the ground, and while near the ground the dust-bearing currents must have been retarded by friction, and hence had then a smaller velocity, and a smaller deflection toward the isobar than is assumed for the upper winds. Curve D (fig. 1), represents the air current starting in northeastern Arizona at 4 p. m. with a velocity of 50 miles per hour (the observed maximum velocity at Flagstaff was 48). The direction is assumed at the beginning to be 45° to the left of the isobar. Increments of velocity of $2\frac{1}{2}$ miles per hour, and of deflection of $3\frac{3}{4}°$ per hour are added each hour for 12 hours, bringing this wind up to the gradient

8, to noon, March 9, while it was advancing over Nebraska and Iowa, indicates exceedingly weak convection. Under these circumstances some of the dust-bearing wind could have made the circuit of the center without having its dust washed down by rain or snow.

Regions of deposition.—The fall of dust was not generally noticed by meteorological observers, so that we are not able to estimate the area covered or the total quantity of material that fell. In this respect conditions are very different from those of European falls, such as those of March 9–12, 1901, discussed by Hellmann and Meinardus (**2**), and of February 22, 1903, by Mill and Lempfert (**7**), for which many reports and measurements by both scientific men and the lay public were available.

By comparing the reports that were received, with the daily weather maps, it appears that cyclone III deposited dust at Madison, Portage, Hancock, Montello, and

Florence, Wis.; at Dubuque, Iowa; at Newberry in upper, and Grand Haven in lower Michigan, and at Chelsea, Vt. Rainfall of cyclone IV brought down dust at Columbus and Oberlin, Ohio, on March 12. The dust cloud accompanying this storm was observed at Tiffin, Wauseon, Pataskala, Plattsburg, Wilmington, and Oberlin, Ohio. In cyclone IV dust fell with snow at Woodstock, Vt., and with mixed sleet and rain at Alstead Center, N. H., on March 14.

Quantity of the dust.—At Madison the dust-bearing snow and sleet was collected from a measured square yard by Prof. W. H. Twenhofel. The quantity of dust obtained from this area amounted to 4 grams. For comparison this is converted to the usual units, in the following table, with the data given for European falls by Free (**1**).

Date.	Place.	Weight of dust.	
		Grams per square meter.	Tons per square mile.
Oct. 16, 1846..	Southeastren France	0.63	1.8
Mar. 31, 1847 .	Tyrol	2.0	5.7
1859	Westphalia	30.0	85.8
February, 1862	Salzburg, Austria	0.08	0.24
Mar. 24, 1862..	Carniola, Austria	5.0	14.3
Mar. 9-12, 1901.	Various places in Europe	11.23-1.0	31.1-2.9
Mar. 19, 1901 .	Taormina, Italy	2.7	7.7
Mar. 9, 1918..	Madison, Wis	4.8	13.5

Gross appearance of the dust.—At Madison, Wis., where the dust was mixed with a good deal of snow, it gave the latter a very light yellowish, or isabeau, tint. At Florence, Wis., "the snow was quite dusty in appearance, as to color a reddish brown;" Chelsea, Vt.—"it was noticed here as brown;" Alstead Center, N. H.—"was of reddish brown color;" Woodstock, Vt.—"snow was yellow and pink;" At Columbus, Ohio—"A peculiar reddish deposit was observed this morning on windows, and on white paint, where the rain of the morning had evaporated;" at Oberlin, Ohio—"produced a visible discoloration on the roofs." After the dust-laden snow began to thaw the surface became black at Madison, "rusty" at Newberry, Mich. The snow at Madison, melted for measurement, became black water, and would doubtless have been called "black rain" if it had fallen as rain.

Analysis of the dust.—The authors have reported elsewhere (**10**) the microscopic and physical analysis of the dust collected at Madison, so that only the following brief summary will be given here.

Microscopic study shows the dust to consist chiefly of minerals, but with some plant tissue, and a considerable number of diatom tests. The proportion of the chief constituents is estimated as follows:

Feldspar and quartz, 65 to 75 per cent.

Amorphous material, including limonite, hematite, kaolin, opal, etc., 20 to 30 per cent.

All other constituents about 5 per cent.

Microscopic measurements of the size of the particles show that they range from about 0.003 mm. to 0.1 mm., but a surprisingly large percentage falls within much narrower limits, namely 0.008 to 0.025 mm. Mechanical analysis of the dust, made by Prof. H. W. Stewart of the department of soils, University of Wisconsin, gives the percentage distribution shown in column No. 1 in the following table:

Size.	1	2	3	Size.	4	5
Mm.				*Mm.*		
0.005	11.15	17.8	11.3	0.004-0.008	1.5	....
0.005-0.010	22.01	....	....	0.008-0.016	14.1	0.7
0.010-0.025	56.17	65.8	74.1	0.016-0.032	36.2	5.2
0.025-0.050	5.99	....	....	0.032-0.125	31.5	42.0
0.05-0.10	1.22	14.0	13.2	0.063-0.125	7.8	42.0
0.10-0.25	1.04	1.5	0.8	0.125-0.250	5.5	10.0
0.25-0.50	0.58	0.2	0.3	0.25-0.50	3.0	Tr.
0.5-1.0	0.29	1.0	0.2	0.5-1.0	0.2	....
1.0-2.0	1.08	0.0	0.0	1.0-2.0	....	....
	99.53	100.3	99.9		100.0	99.9

1. Dust from snow fall at Madison, Wis., Mar. 9, 1918.
2. Soil, Hays, Kans., which is subject to blowing. E. E. Free. "The Movement of Soil Material by the Wind, U. S. Bur. Soils, Bulletin 68, p. 168, 1911.
3. Silt loam soil ("Waukesha") from valley loess, Douglas County, Nebr., A. H. Meyer, et al., U. S. Bur. Soils, 15th Rept., p. 1994, 1913.
4. Dust from dust shower, Chicago, Ill., February, 1896. J. A. Udden, The Mechanical Composition of Wind Deposits, Augustana Libr. Pub. 1, p. 55, 1898.
5. Volcanic dust which fell on snow in Norway after a recent eruption in Iceland. J. A. Udden, l. c., p. 36.

For comparison similar analyses of soils, volcanic and atmospheric dusts are also given. This shows that the Madison dust is finer than the other dusts, and that a larger percentage of it is within a small range of sizes. Some soils contain much larger amounts of clayey material (0.005 mm.), but few contain as much silt (0.005 to 0.050 mm.); on the other hand, shower and volcanic dusts contain much less clay than the Madison dust. This may be due to the falling of shower and volcanic dusts wholly through the action of gravity, while the Madison dust was brought down, not by its own weight, but by the weight of the snow or rain condensed upon it.

A sample of dust collected by Prof. G. F. Wright at Oberlin, Ohio, on March 12, 1918, is strikingly similar to the dust that fell at Madison, consisting of the same minerals, the same spores and other organic fragments, and the same diatoms, although these seem to be decidedly rarer than in the dust that fell in Wisconsin.

The organic constituents of the Madison dust have been examined microscopically by Prof. R. H. Denniston of the department of botany of the University of Wisconsin, and he has been able to identify fragments of blades of grass, of leaves of clover or some similar legume, fibers of cotton, and of coniferous wood, all more or less decayed, and carrying saprophytic fungi and their spores.

Conclusion.—The importance of the wind in eroding and transporting soil material, in building soils, and in transporting spores of both useful and pathogenic organisms for long distances; and of the influence of atmospheric haze upon the absorbing and radiating power of the atmosphere, is so great that opportunity to collect quantitative data regarding them afforded by the observation of the phenomena of dustfalls should be taken advantage of by observers. Discolored snow and rain, from measured areas, such as that of the ordinary rain gage, should be evaporated, and the sediment forwarded to mineralogists or soil physicists for examination. The beginning and ending of the discolored precipitation should be specially recorded. It is also very desirable that fuller records of the haziness of the sky, red sun or moon, with the time of incidence, be made by meteorologists.

REFERENCES.

1. FREE, E. E. The movement of soil material by the wind, U. S. Bureau of Soils, Bulletin 68, Washington, 1911.

2. HELLMANN and MEINARDUS. Der grosse Staubfall vom 9 bis 12 Marz, 1901, in Nordafrika, Süd- und Mitteleuropa. Abh. K. Preuss. Met. Inst. vol. 2:pt. 1, 93 pp. 1901.

3. HUMPHREYS, W. J. Dust layers in the atmosphere, etc. Bulletin Mount Weather Obs. 4:pt. 6:397–401.
4. HUMPHREYS, W. J. Volcanic dust and other factors in the production of climatic changes, etc. Bulletin Mount Weather Obs. 6:pt. 1:1–34.
5. HUMPHREYS, W. J. Nomogram of gradient velocities, in physics of the air, Journal of the Franklin Institute, November, 1917, page 673, revised.
6. KIMBALL, H. H. The effect upon atmospheric transparency of the eruption of Katmai volcano. Monthly Weather Review, 41:153–159, January, 1913.
7. MILL and LEMPFERT. The great dustfall of February (19–22), 1903, and its origin. Quart. Jour. Roy. Met. Soc., Vol. 30, 1904, pp. 57–91.
8. SHAW, SIR (W) N. The travel of circular depressions and tornadoes. Meteorological Office, Great Britain, Geophysical Memoirs No. 12. London, 1918. Reviews: Quart. Jour. Roy. Met. Soc. Oct., 1918, 44:290-294; Nature, London, Sept. 26, 1918, 102:69.
9. SHAW and LEMPFERT. The life history of surface air currents, Met. Office, 174, London, 1906.
10. WINCHELL, A. N., and MILLER, E. R. The dustfall of March 9, 1918. Am. Jol. Sci. 46:pt. 10, 599–609.

SMOKE FROM MINNESOTA FOREST FIRES.

By HERBERT LYMAN.

[Dated: Weather Bureau, Washington, Jan. 2, 1919.]

A phenomenon of perhaps more than passing interest was witnessed from October 13 to 17, when smoke

FIG. 1.—Wind distribution, 8 a. m., Oct. 12, 1918.

clouds from the great forest fires of Minnesota and adjacent sections of Wisconsin rapidly spread over a large portion of the United States east of the Missouri River. These fires, of which there were no less than six[1] large ones, started on October 12, 1918, following a long period of exceptionally severe drought during which the precipitation had averaged only 20 to 25 per cent of the normal. To those interested in meteorology, however, the most interesting phase of the great fires is the remarkable rapidity with which the smoke traveled. Thus, in a little over 24 hours the smoke, borne by northwest winds, reached the Atlantic seaboard, and in another 24 hours had been carried as far south as Charleston, S. C.

To trace the development and course of the smoke cloud a series of charts (figs. 1 to 8) is presented. These were made up from the Washington daily weather maps and from the monthly reports of a number of regular and cooperative Weather Bureau stations within the area under discussion.

Figure 1 shows a moderate barometric disturbance along the northern border of Minnesota and Lake Superior on Saturday morning, October 12, only a few hours before the forest-fire smoke was first noticed. In Duluth, which was quite near the conflagrations, the weather was fine and clear in the morning. Shortly

FIG. 2.—Wind and smoke distribution, p. m., Oct. 12, 1918. "Sm"=light smoke; "Sm" in circle=dense smoke.

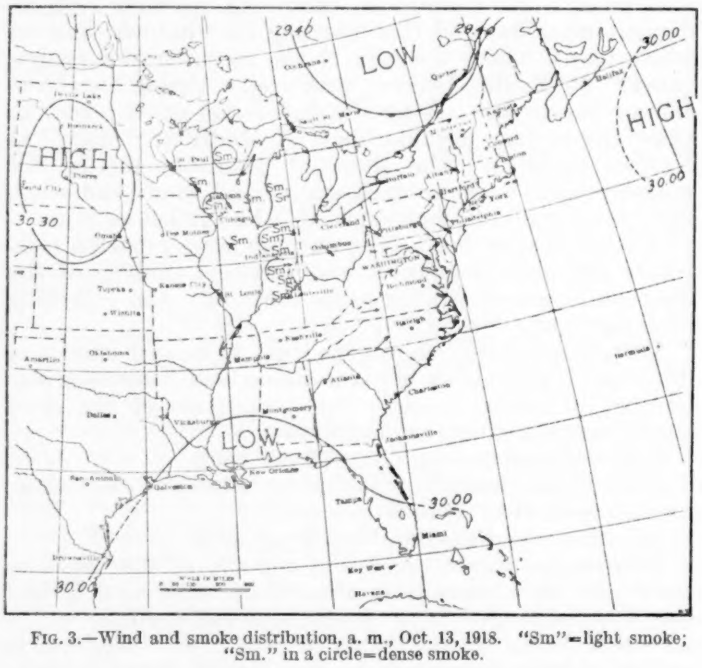

FIG. 3.—Wind and smoke distribution, a. m., Oct. 13, 1918. "Sm"=light smoke; "Sm." in a circle=dense smoke.

before noon smoke appeared in the west and became rapidly denser until 3 o clock when the sun was entirely obscured. By 4:30 p. m. the city lights had to be turned on. Figure 2, shows the cyclonic depression covering the entire Lake region with the center over Montreal. By the following morning, October 13 (fig. 3), this LOW had

[1] From a report to the U. S. Forest Service by National Forest Examiner John McLaren.

moved to eastern Ontario, while in the West a high area had advanced to the Dakotas. Twelve hours later the LOW had reached the mouth of the St. Lawrence (fig. 4). With high pressure continuing in the Dakotas and a shallow LOW in the Gulf, northwesterly winds naturally

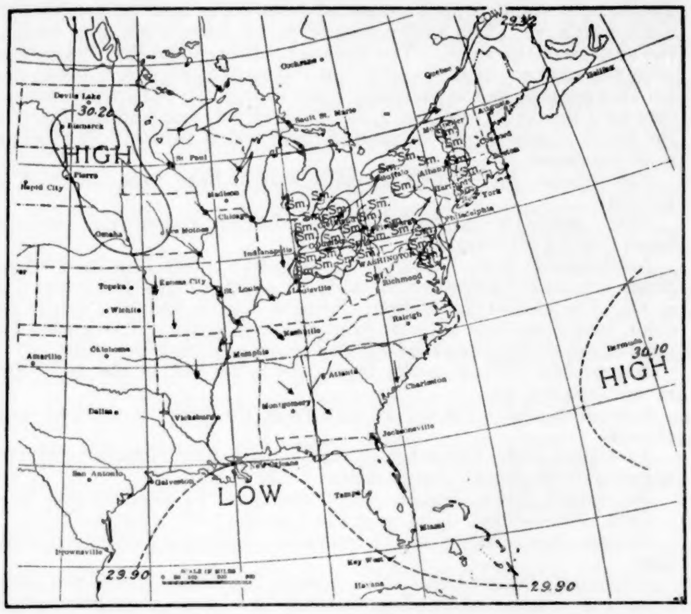

FIG. 4.—Wind and smoke distribution, p. m., Oct. 13, 1918. "Sm"=light smoke; "Sm." in a circle=dense smoke.

prevailed from Minnesota eastward thus carrying the smoke cloud to the Atlantic coast by about 10 p. m. of the 13th.

The chart for the morning of the 14th (fig. 5) shows the Dakota HIGH extending eastward to Ohio and southwest-

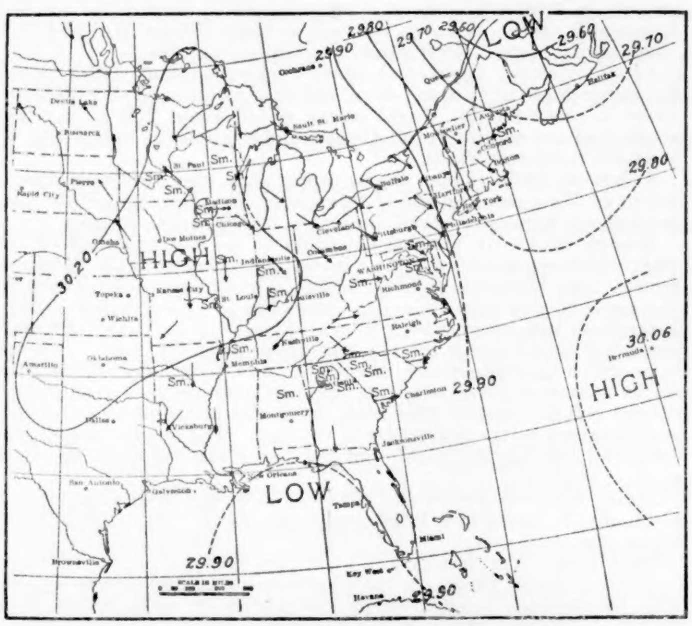

FIG. 5.—Wind and smoke distribution, a. m., Oct. 14, 1918. "Sm"=light smoke; "Sm." in a circle=dense smoke.

ward to northern Texas. In the Gulf the pressure is still low. This pressure system resulted in winds that carried the smoke southward to Little Rock, Ark., on the west, and to Charleston, S. C., on the Atlantic coast. By the night of the 14th (fig. 6) the HIGH had moved eastward, occupying the Lower Lakes and the Ohio Valley. At the same time a LOW was centered over Pierre, S. Dak., and another over the Gulf. The resultant winds spread the smoke still farther southward beyond College Station, Tex., in the west, and Thomasville, Ga. in the east.

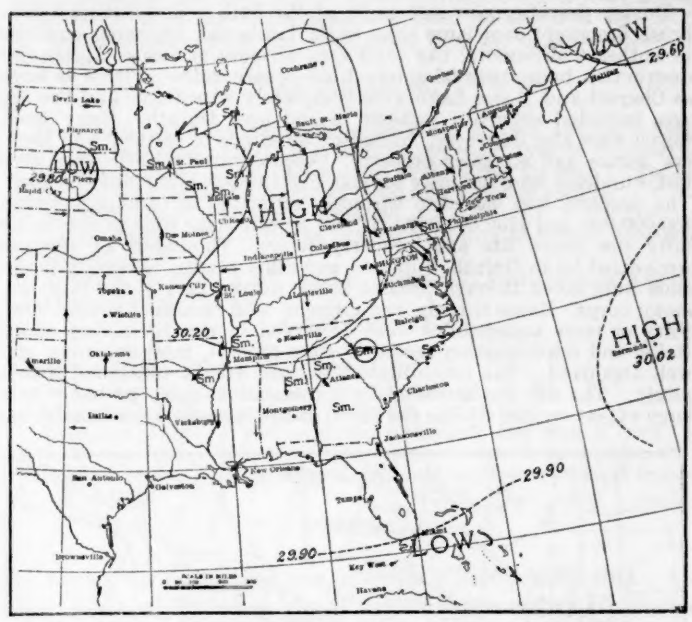

FIG. 6.—Wind and smoke distribution, p. m., Oct. 14, 1918. "Sm"=light smoke; "Sm." in a circle=dense smoke.

Figure 7 (p. m., Oct. 15), with easterly winds at North and South Dakota stations, shows how the smoke drifted westward from Minnesota.

Figure 8 (p. m., Oct. 16) shows the smoke cloud still covering a wide range of territory, extending from Valen-

FIG. 7.—Wind and smoke distribution, p. m., Oct. 15, 1918. "Sm"=light smoke; "Sm." in a circle=dense smoke. Smoke also in E. Texas.

tine, Nebr., to Portland, Me., and from the Lakes to Little Rock, Ark., and Greenville, S. C.

Extracts from the meteorological notes of a number of regular and cooperative Weather Bureau stations, and from other interested observers are appended:

OCTOBER 12.

Duluth, Minn.—**The outstanding feature of the month was the 50 to 60 mile westerly gale which occurred on the afternoon and night of the 12th and which was attended by the devastating forest fires which swept over this section at that time, resulting in enormous loss of life and property.**

During the afternoon and night of the 12th a devastating forest-brush fire swept over large areas in St. Louis and adjoining counties in notheast Minnesota, the total area of more or less complete fire destruction being approximately 1,500 square miles. Places as large as Cloquet and Moose Lake were completely wiped out, and the fire area included suburban sections in and near Duluth. Many small towns were also destroyed, including hundreds of settlers' and farmers' homes and all their property. Approximately 1,000 lives were lost, hundreds were seriously burned, and thousands narrowly escaped. The property loss has been variously estimated as running between $50,000,000 and $100,000,000. It will require some time to determine fully the exact life and property losses. Thousands of refugees were cared for in Duluth, Superior, and other places. Literally thousands were saved through prompt action on the part of the railroads, motor corps, Home Guards, and citizens, who furnished automobiles. Fifty or more automobiles were destroyed in this life-saving effort. Relief and rehabilitation measures were prompt, most generous, and well organized. The rehabilitation feature will be continued indefinitely. The fire was attended by a tremendous gale,[1] probably to a large extent created by the fire itself, as the meteorological conditions

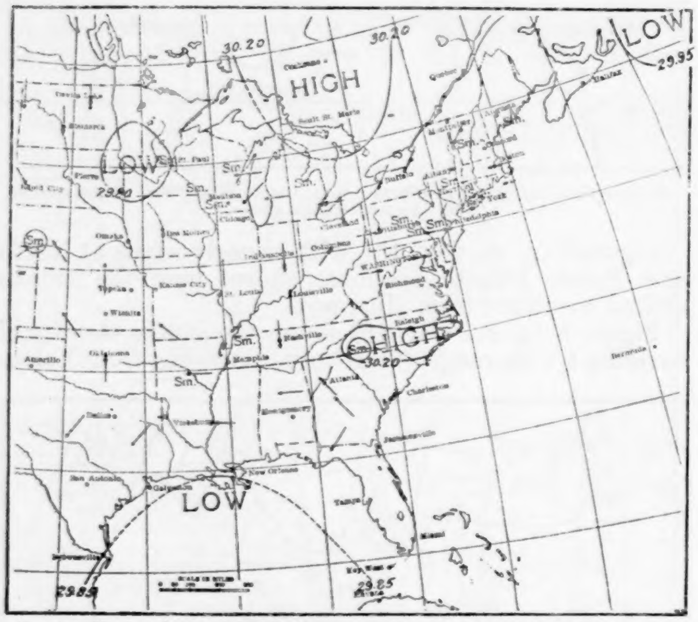

FIG. 8.—Wind and smoke distribution, p. m., Oct. 16, 1918. "Sm"=light smoke; Sm. in a circle=dense smoke.

favored but a fresh wind. During the worst period of the fire (4 p. m. to 9 p. m.) the wind blew at rates varying from 50 to 65 miles per hour and from westerly directions. Brush and peat bog fires had been burning for some time previous, but no grave danger was anticipated. The fire's progress and development were enhanced by reason of the prevalent record-breaking dry season and the fresh wind which developed on the date of the catastrophe. Such warning as was immediately possible was duly made, and the probability of such a fire had been given some previous attention on the part of the forest rangers and others.

OCTOBER 13.

Madison, Wis.—Dense smoke from Minnesota forest fires began during the night. Continued smoky all day, probably not enough to be called "dense" in the afternoon. Moon and stars visible near the zenith in the evening, but stars obscured near the horizon.

Wausau, Wis.—Smoke from the forest fires in northern Minnesota was observed.

Grand Haven, Mich.—On the 13th the entire sky was colored pink before and at sunrise; shortly after sunrise it rapidly took on a yellowish-green hue. Light smoke prevailed at the time. The green faded rapidly as the sun rose higher. The smoke was almost dense from 8 a. m. to 11 a. m.

[1] The gale may have been the result (1) of a local heat cyclone produced by the fire, and (2) of the large amount of convectional interchange which brought to the earth great quantities of the higher, more rapidly moving air.—ED.

Lansing, Mich.—On Sunday morning, October 13, a dense sheet of smoke filled the atmosphere, causing a peculiar coppery color of the sunlight. On the previous day there occurred extensive forest fires in Wisconsin and Minnesota, and it is thought that the northwest winds then prevailing may have brought the smoke to this station.

Port Huron, Mich.—On the morning of the 13th the early morning light was of a peculiar greenish-yellow color, which was doubtless due to light smoke which prevailed from some time before daylight until 8:30 a. m. The smoke seemed to be more thick aloft than at the surface of the earth. The peculiar aspect of the sky disappeared with the smoke. It is thought that the smoke came from forest fires which were reported in the daily press as burning in northern Minnesota for a day or so previously, as the wind was west and northwest at the time. Some people became alarmed and inquiries were received as to the cause.

Fort Wayne, Ind.—Light smoke and light haze were observed on the 13th.

Howe, Ind.—The sun looked like a red moon, caused from smoke of forest fires [in Minnesota].

Indianapolis, Ind.—Smoke from extensive forest fires in northern Minnesota and Wisconsin first made its effect noticeable here at 8:30 a. m. The sun's rays gradually became fainter and of a bright red color, and there was an odor as of burning leaves. The smoke was most dense in the late afternoon and lessened during the night.

Mauzy, Ind.—Dense smoke during the latter part of the day. Sun invisible at 5 p. m.

Salamonia, Ind.—Smoky all day from the great forest fires near Duluth.

Scottsburg, Ind.—Quite heavy smoke, with odor of burning leaves, appeared from the northwest at about 4:30 p. m.

Bangorville, Ohio.—Smoke very dense from the northwestern fires.

Cadiz, Ohio.—Smell of burning wood on the 13th; very smoky.

Canton, Ohio.—Heavy smoke from forest fires on the afternoon of the 13th.

Cincinnati, Ohio.—Unusual conditions prevailed during the afternoon and evening of Sunday, October 13. Cloudy weather, which prevailed during the early morning, cleared at about 7:30 a. m. The sky was clear until shortly after noon, when a few cirrus clouds had formed. Thereafter the sky was gradually covered with a haze and smoke, which was moderately dense from 1:20 p. m. to 2:10 p. m. After this time the smoke virtually disappeared, and while light haze was visible, no cloud formation could be seen. At 3 p. m. the smoke and haze became denser, but the sun's light and its disk could be seen until 3:35 p. m., at which time the sun was entirely obscured. Objects at this time could not be seen at a distance of 300 feet. Similar conditions prevailed in all surrounding regions. At 3:45 p. m. the haze and smoke, although dense, were not sufficient to obscure the sun and it was still visible as a dim red ball at both College Hill and Fort Thomas, Ky., two of the highest neighboring localities.

Cleveland, Ohio.—Light smoke was first observed shortly after 6 a. m., becoming dense at 11 a. m., dense smoke continuing until 1:30 p. m., when it became light. Light smoke ended about 2:25 p. m. The smoke had the odor of burning brush, and was brought to this city by west and northwest winds.

Columbus, Ohio.—Dense smoke, apparently from the forest fires of northeast Minnesota, prevailed throughout the afternoon of this date, gradually merging into cloud during the late afternoon hours.

Dayton, Ohio.—An unusual condition of the sky prevailed on the 13th, which was assumed to be directly connected with the extensive forest fires in Minnesota and Wisconsin. The sky was overcast early in the morning with strato-cumulus clouds but the lower stratum of the atmosphere was comparatively clear. About 8 a. m. the clouds dissipated and for two hours the sky was almost perfectly clear. It began to present a hazy appearance about 10 a. m. Within half an hour the smoke became so dense as to give the sun the appearance of an orange-colored ball and shortly after noon it was almost completely obscured and remained so the remainder of the day. The smoke disappeared completely during the night, but the moon was obscured up to 10 p. m. or later.

Hiram, Ohio.—A yellow sky with blood-red sun from 10 a. m. to 2 p. m., due to smoke from forest fires in Minnesota. The smell of burnt leaves was plain.

Lima, Ohio.—Very smoky.

McConnellsville, Ohio.—In the afternoon the landscape was covered with smoky haze brought in by the northwest winds which blew strongly. The sun appeared as a red ball.

Ottawa, Ohio.—A peculiar yellow tint prevailed over this vicinity; also told that same was true at Toledo by persons living there, who thought it was caused by smoke of the Wisconsin fires.

Sidney, Ohio.—Smoke settled in valley here from Wisconsin forest fires.

Vickerey, Ohio.—Very smoky all the forenoon from Minnesota and Wisconsin forest fires.

Albany, N. Y.—On Sunday afternoon, October 13, 1918, a light rain accompanied by an unusual smoky condition of the air was observed at my laboratory 9 miles west from Albany, N. Y. The conditions were as follows: During the afternoon there was a steady wind from the south

of about 4 miles per hour measured at the evaporation station anemometer 2 feet above ground. The sky was partly overcast with clouds at medium height. At 4:35 p. m., clock time, the wind was heard rushing through the woods at some distance, the sky became suddenly overcast with low uniform clouds, there was a sudden gust of strong wind from the west accompanied and followed by dense smoke with a strong smell of burning wood. The temperature dropped from 62° to 51° and the rainfall measured by the Friez recording gage was 0.05 inch between 4:49 and 5:02 p. m. The appearance and odor of smoke was so strong and came so suddenly that one instinctively looked about for a fire in the woods.

The conditions apparently were produced by a layer of cool air underrunning the sluggish, warm and humid surface air which had prevailed throughout the afternoon, forcing it upward with extreme suddenness and producing the light rain. Being interested in the question of the origin of the smoke I made inquiries at Little Falls, located 73 miles west from Albany in the Mohawk Valley, and learned that substantially the same phenomenon as regards wind conditions and the appearance and odor of wood smoke were observed there at very nearly 4 p. m., clock time. * * * In view of the prevailing forest fires of Minnesota the question arises as to the possibility of a connection between this smoke-bearing wind gust and these fires. The air in the Mohawk Valley had been remarkably clear for this season of the year prior to the smoke storm of October 13.—*R. E. Horton.*

Brockport, N. Y.—Sunday, October 13, the light was a curious greenish-yellow until after 2 p. m.

Ithaca, N. Y.—Atmospheric conditions of Sunday, October 13, presented a heavy, smoky appearance in the northern and western sections of the State. The sun and sunlight took a curious greenish-yellow appearance which, in some respects, was not unlike full moon and moonlight in some localities, while in other parts the atmosphere seemed to have been filled completely with a dismal contour of hazy yellow clouds, causing the day to be termed by some as a "yellow" day. In still other places the sun appeared like a bright ball of fire peering through the hazy sheen. Unquestionably the peculiar appearance was due to a heavy pall of smoke, which is believed to have been wafted eastward and southeastward over the Great Lakes by high winds of a strong anticyclonic area of atmospheric pressure from the northeastern sections of Minnesota, where disastrous forest fires that destroyed several towns and cost many lives, raged for some days previous to the "yellow" day of the 13th.

Raquette Lake, N. Y.—From 4 to 5 p. m. unusual sun and sunlight, more like full moon and moonlight.

Wedgwood, N. Y.—A dense smoke with smell of burning leaves observed in the p. m. The sun appeared like a ball of fire.

Burlington, Vt.—Atmosphere very smoky in the afternoon, clearing away shortly after sunset.

New Haven, Conn.—Light smoke was observed during the evening.

Pittsburgh, Pa.—On the 13th dense smoke having a woody odor was observed in the afternoon during a 20-mile wind. The sky was almost copper-colored and the pungent, acrid odor was noted throughout the Pittsburgh district, causing difficulty in breathing, a smarting and burning of the eyes.

Elkins, W. Va.—The smoke of the 13th is believed to have been due to the great Minnesota fires.

Smithfield, W. Va.—On Sunday evening, October 13, for some hours the town was filled with smoke from forest fires in west.

Baltimore, Md.—Light smoke set in at 9:50 p. m. and became dense at 10:15 p. m.

Washington, D. C.—A beautifully clear evening until about 10 p. m., when light smoke, with a strong odor of burning wood, was noticeable. By 10.30 p. m. the smoke cloud became denser, and was distinctly visible over the face of the moon. By 11 p. m. the moon and stars had disappeared, and street-lights half a block distant were appreciably dimmed.

OCTOBER 14.

Madison, Wis.—Dense smoke from some time in the night to 9 a. m. Light smoke from 9 a. m. to some time during the night.

Wausau, Wis.—Smoke from the forest fires in northern Minnesota and Wisconsin was observed.

Portland, Me.—Light smoke observed.

Elkins, W. Va.—Smoke on the 14th believed to have been due to the great Minnesota forest fires.

Greenville, S. C.—Light smoke from early morning until about 10 a. m., which merged into a light haze during the following night.

OCTOBER 15.

Washington, D. C.—Dark layer of haze or smoke on the western horizon in the morning increased in elevation and became lighter in color as the day advanced.

Macon, Ga.—Sky covered most of the day with Ci. St. clouds moving from the west and northwest. With these there was a generally hazy or smoky condition of the air strata.

Thomasville, Ga.—Light smoke was observed to-day.

College Station, Tex.—At 8.20 a. m. there was an unusual amount of haze; and at 10:40 there was a well-defined smell of forest fire smoke and the haze had become dense. Evidently, this was smoke from the Minnesota fires having come in the lower air around the front of the large north-south high pressure area.—*C. F. Brooks.*

Devils Lake, N. Dak.—Mention is made of the smoky condition of the atmosphere. Easterly winds on the 15th and 16th drifted the smoke from the large forest fires of northern Minnesota over this district.

Ellendale, N. Dak.—Light smoke occurred on the 15th and 16th. It was no doubt due to the great forest fires raging in northeastern Minnesota.

OCTOBER 16.

Ludington, Mich.—Considerable smoke on th 16th and on several days previous, due mostly, it is thought, to forest fires in Minnesota.

Columbus, Ohio.—Light smoke noted in the upper air from 1:30 p. m. to 5 p. m. Aviators at a height of 3,500 feet were not visible.

Portland, Me.—Light smoke recorded.

College Station, Tex.—Smoke limited visibility to 3 km., odor still apparent.—*C. F. B.*

Williston, N. Dak.—Light smoke, presumably from forest fires in the northeast during the day.

OCTOBER 17.

Portland, Me.—Light smoke recorded.

College Station, Tex.—Most of smoke gone.—*C. F. B.*

Lodge Pole, Nebr.—Smoke so dense can not see sun.

Valentine, Nebr.—A pall of smoke hung over this station from the 17th to the 19th, inclusive. This smoke came from northeastern Minnesota, where disastrous forest fires had raged several days before.

SUMMARY.

From the foregoing the following facts stand out. On the 12th of October great forest fires raged in northeastern Minnesota and adjoining portions of Wisconsin. At Duluth the smoke became dense about the middle of the afternoon. By the following morning (13th) the smoke cloud had overspread the Michigan Peninsula and central Indiana. In the next 12 hours strong northwest winds had extended this cloud across Ohio into New York, Pennsylvania, West Virginia, Maryland, and the District of Columbia, the two latter being reached shortly after 10 p. m. On the morning of the 14th, the smoke had spread as far south as Charleston, S. C. and Little Rock, Ark., and in another day more than 300 miles farther. On the 15th, easterly winds set in in western Minnesota. The smoke cloud was carried across North Dakota on the 16th and into Nebraska on the following day.

EFFECTS OF HURRICANES ON THE UPPER-AIR CURRENTS.

By Prof. WILLIAM H. PICKERING.

[Dated: Harvard College Observatory, Mandeville, Jamaica, B. W. I., Dec. 10, 1918.]

A short note under the above heading appeared in the MONTHLY WEATHER REVIEW for October, 1915, **43**, 496–497.[1] A piece of negative testimony on the same subject has just been obtained here. It was there shown that if we pointed a telescope to a bright star near the zenith, and then drew out the eyepiece 2 or 3 millimeters, so as to throw the image out of focus, a round disk of light would be obtained from which we could draw conclusions as to the condition of the upper air currents. In the temperate zone parallel lines crossing this image are not infrequently seen. They never appear in the tropics, however, unless some serious disturbance is at hand. They then lie in a direction parallel to the motion of the disturbance. In September, 1915, we were in this manner able to foretell a hurricane

[1] There is a longer, illustrated article by A. E. Douglass on "The study of atmospheric currents by the aid of large telescopes, and the effect of such currents on the quality of the seeing," in Am. Meterological Jour. 1895, **11**:395-409.—*Ed.*

whose center was at a distance of 750 miles, some 20 hours before we received the Government notice of its presence, and two days before the center reached us.

On Thursday, August 22, of the present year we received our first notice from the United States Weather Bureau of a disturbance located to the southeast of Barbados. On August 23 we were warned by the local bureau to take all possible precautions as the disturbance would probably reach us on Saturday morning. Friday night was clear, and we hastened to the telescope, but to our surprise not a trace of any hurricane lines could be found. The star image was "moulding," however—that is to say, it looked as if it were being moulded by the fingers first in one place and then in another. This indicates local atmospheric disturbances. The seeing was poor, 6, later dropping to 5 on a scale of 12, but was not extremely bad, such as is the case in the vicinity of a hurricane. We therefore retired considerably relieved, in spite of the warnings. The next day the sky was heavily overcast, but with no rain and only moderate winds, and we were informed by the United States Weather Bureau that there was no definite information as to the location of the disturbance. As it turned out the hurricane either had not developed or had taken a more northerly course.

From this we conclude that telescopic observations of the kind described are of value in the local forecasting of tropical storms, not only to foretell their approach and the direction of their motion, but also sometimes to inform us that other indications are not to be trusted.

OCEAN TEMPERATURES IN LONG-RANGE FORECASTING.

By CHARLES F. BROOKS.

[Paper presented at the Baltimore meeting of the Association of American Geographers, Dec. 28, 1918.]

"Besides trying to predict the extremely variable state of the fickle atmosphere one should give more attention to the conservative element of meteorology, viz, the surface sheet of the ocean where changes may be observed months before their effect on our weather becomes manifest. [For example] a sensible departure from the average value of the vast amount of stored heat carried through the [Florida] Straits might have profound effects on the weather of the following months on the European and North American Continents."

These two sentences by Dr. Hans Petterson[1] led me to compare monthly departures of air temperature at stations in the eastern United States with those in the Gulf Stream. Encouraged by the results, I extended the investigation backward into the make-up of the Gulf Stream and Antilles Current, forward into the movement of the Gulf Stream Drift, and the effects of the Labrador Current, and upward into the influence of water temperatures on the overlying air. A report on the preliminary results just a year ago led to the active cooperation of the Weather Bureau in mapping more data, and later the Signal Corps offered additional help.

Let me outline the general basis which seems to make worth while the contemplated extensive investigation of ocean temperatures in long-range forecasting. If it is possible (1) to forecast the distribution of surface water temperature a few weeks in advance, it may prove possible (2) to forecast the general paths which will be followed by cyclones and anticyclones; and then (3), from the winds which will result, to make long-range forecasts of the general weather to be expected in any period. Let us consider each of these points more in detail.

1. *How do water surface temperature departures originate and move?*

Insolation and radiation are the most important factors in the general heating and cooling of the ocean surface. The temperature of the air is of little consequence in the heating, and still less in the cooling, of the ocean surface, for the specific heat of water per unit volume is about 3,300 times that of air under ordinary conditions.

Departures of the temperatures of the sea surface from the normal are almost wholly the result of variations in wind direction and velocity. Helland-Hansen and Nansen have shown in their recent book[2] that in middle latitudes of the Atlantic the wind direction is largely responsible for the occurrence of plus and minus temperature departures. Following a winter month with the prevailing wind north of the normal over any region, the water temperatures are almost invariably below normal, while a month with prevailing winds south of normal is followed in the next by water temperatures above normal. The air temperature, of course, shows similar, though greater and more immediate, departures. The coldness or warmness of the water is probably dependent more on transportation of water from colder or warmer latitudes than on the cooling or warming by the wind which is driving it. At any rate the evaluation of each factor is of little consequence for both act to produce the same result.

The effect of changes in wind velocity is most noticeable in the Tropics, where changes in direction are of little or no effect. When the trade winds are unusually strong for a period, the warm layer of surface water is driven forward and concentrated in the Equatorial Current, where it forms a plus departure in temperature. The place of this warm surface sheet is taken by cooler subsurface water, making a minus departure. Under the influence of the wind the area of plus departure followed by that of minus moves slowly westward. Using Hepworth's data,[3] I found that most months of unusually strong northeast trade winds in the eastern Atlantic are followed in 4 to 6 months by plus departures in the temperature of the surface water passing through the Straits of Florida, and in 8 to 11 months by minus departures. The southeast trade in the eastern Atlantic, acting through the South Equatorial Current, part of which feeds the Gulf Stream, produces a similar plus and then minus departure in the Straits of Florida, 6 to 9 and 10 to 14 months, respectively, after the month of unusually strong southeast trade.

What happens to these waters of varying temperature as they debouch into the Atlantic? The strength of the Gulf Stream carries them forward to the region south of Nantucket within a month; but their identities are not lost for several months more in the case of water markedly warmer or colder than usual. In fact, in spite of the obliterating effects of shifting winds of varying strengths, many of the water temperature departures observed in the Gulf Stream, Antilles Current, or Labrador Current are discernible many months later on the coast of Europe, especially when the water has made most of the transit in the quieter months of the year. From the Straits of

[1] Meteorological Aspects of Oceanography, M. W. R., June, 1916, 44: 338-341, 2 figs.

[2] Temperatur-Schwankungen des Nordatlantischen Ozeans und in der Atmosphäre Christiania, 1917. See author's abstract, M. W. R., April, 1918, 46: 177-178.

[3] M. C. W. Hepworth, The Trade Winds of the Atlantic Ocean. Metl. Office, London, No. 203, 1910.

Florida to the edge of the European continental shelf at about latitude 50 degrees, the temperature departures take 8 to 10 months. The effects of changes in the Labrador Current on the Grand Banks take equally long. But the departures in the Antilles Current east of the Bahamas take but 5 to 7 months to cross the Atlantic.

Think of the travels of an important plus temperature departure, for instance, between latitudes 5° and 45° in the North Atlantic. Originating, perhaps, in the eastern Atlantic during a month of strong trades (the strength of which may still farther back depend on the water temperature distribution) and proceeding across the Atlantic, many of these departures in the course of 4 to 6 months pass through the Straits of Florida; and in 8 to 10 months more they may be felt off the west coast of Europe. Thence some of the important departures may complete the circuit and appear in the Straits of Florida 15 months still later. In spite of the great complexities introduced by changing winds, it is evident that there are possibilities of forecasting the distribution of ocean surface temperatures.

2. *How do these ocean temperatures control atmospheric pressure and winds?*

It is a matter of common knowledge that in autumn and winter in middle and high latitudes bodies of water are marked by low pressure areas because of their warmth, and in spring and summer by high pressure areas in the regions where the water is appreciably colder than the land. Many investigators have shown that this is true for particular months, and that peculiar water temperature distributions are marked by corresponding pressure features. As weather forecasters well know, the individual cyclones tend to follow paths across the warmer regions and to be intensified where there are sharp contrasts in temperature; and the anticyclones tend similarly to follow paths across the colder regions and to maintain the highest pressures over the coldest parts.

J. Petersen has described in detail how the Iceland LOW moves back and forth between southern Greenland and the Norwegian Sea in response to the changing distribution of water temperatures induced by its own winds.[4] When the Iceland LOW is west, the strong southwest winds in the eastern Atlantic bring warm air and drive warm water far northeastward; while northerly winds along the Greenland coast bring cold water southward. The rise of temperature in the east and the fall in the west favor a fall of pressure in the east and a rise in the west. Consequently, the center of lowest pressure moves eastward. But when the Iceland LOW is centered in the east, the northwest winds west of the British Isles drive cold water toward the coast of Europe; while farther north, warm water is being driven westward. The resulting cooling in the east and warming in the west favor a return of the center of the Iceland LOW to its first position; and the cycle begins anew.

The general circulation of the atmosphere favors high pressures in latitudes 25° to 40° and low pressures between latitudes 50° and 65°. The particular locations of the permanent and semipermanent centers of high pressure are likely to be the coldest spots in the low-latitude belt; while the centers of general low pressure will probably be in the warmest spots of the high-latitude belt. The intensities of these centers of action seem to be functions both of the strength of the general circulation and of the temperature contrasts in approximately the same latitudes.

[4] "Unperiodische Temperaturschwankungen im Golf Strom und deren Beziehung zu der Luftdruckverteilung." Am. d. Hydrog u. Mar. Met. 1910, 38:397-417, 2 pls.

3. *What weather occurs with winds which accompany any pressure type?*

A body of unusually warm water coming through the Straits of Florida, as in January, 1916, on spreading over the western Atlantic south and east of New England makes a very favorable region for cyclones. In consequence, we experience such unusual cold and snowy north and northeast winds as made the snowy winter of 1915–16 famous in the Middle and North Atlantic States.[5] In February, March, and April, of 1916, many cyclones approaching the Atlantic coast passed eastward, out to sea; became intense over the warm water, and then weakened over the cooler water beyond.[6] Thus, we have the paradox that an unusually warm Gulf Stream favors cold weather in the eastern United States, while a "cool" Gulf Stream favors warm weather.[7]

For the different pressure types the weather is well known, both in Europe and in this country; so, if the probable position and strength of the center of action can be forecast, the details will follow easily.

It is evident that general answers of a favorable kind, even though not firmly established, are already at hand for the three questions, and that much work has already been done. It remains to coordinate these results and to add considerably to the data already mapped. While we might be able to compute the subsequent pressure distribution from the present surface temperatures and winds, the problem is too complicated to be solved quickly in this way. We need to attack this problem in the same way that the daily forecasting difficulties were met; make a thousand maps, classify them according to types, and forecast empirically if the dynamic basis is not clear. While this is simple to say, the use of ocean temperatures in long-range forecasting will be a tremendously complicated proceeding. It seems probable that certain types of pressure distribution, as averaged for 10–30 day periods, can be associated with certain types of surface water temperature distribution. In making a forecast of the pressure distribution for month after next, for instance, it might be necessary to go through the following procedure: (1) Forecast how the water temperatures will change during the next 10 days under the action of the present winds; (2) forecast a slight rearrangement of the tracks of cyclones and anticyclones in accordance with this changed water surface temperature distribution; (3) apply the winds of this forecast pressure distribution to the movement of the water for the next 10 days; (4) go through the round a few times more; (5) as some kind of a check compare the results with the sequences on previous occasions following similar original pressure and water-temperature associations. Longer-range, more general forecasts might be made by watching closely the Gulf Stream in the Straits of Florida and the Japan Current off Formosa.

POSSIBLE APPLICATIONS TO THE NORTH PACIFIC REGION.

[Conclusion of a paper on "Possibilities of Long-Range Seasonal Weather Forecasts Based on Ocean Temperatures: With Especial Reference to an Investigation of the North Pacific," read at the conference on this subject during the semicentennial celebration of the founding of the University of California, Mar. 18-21, 1918.]

The first steps for an investigation of the North Pacific Ocean, in particular, would be to procure plenty of current atmospheric pressure and temperature data. The area is so vast that if we are to have a satisfactory

[5] Cf. New England Snowfall, M. W. R., June, 1917, 46: 271-285, and Geogr. Rev., Mar., 1917, 3: 222-240.

[6] See the discussion of the marine data for November, 1917, on chart IX and p. 538 of this issue of the Review for a somewhat similar occurrence of a southwestward displacement of the Iceland LOW over an area of unusually high water temperatures.

[7] Cf. The "Old-Fashioned" Winter of 1917-18, Geogr. Rev., May, 1918, 5: 405-414.

picture of the weather and water conditions of the Pacific Ocean, all ships and all lighthouses operating in this region should be equipped to take water temperature and atmospheric pressure observations. These observations should be made available within a month of the time they are taken, if possible at some international establishment where they can be used immediately for the construction of maps. At this bureau, there could be a corps constantly engaged in mapping the data, getting averages for 10-day and 30-day maps, and making the computations necessary for the construction of forecast maps.

On the research side a profitable beginning has been made by T. Okada[8] and others in their investigations of weather correlations in the Pacific region. In closing, I wish to call attention to the desirability of applying to the Pacific certain correlations which have been worked out for the Atlantic Ocean. P. H. Gallé is now making winter temperature forecasts for central and western Europe on the basis of the strength of the trade winds during the preceding May to October.[9] February to March and March to April temperatures for the same region are indicated fairly well by the pressure gradient between Copenhagen and Stykkisholm during the preceding September to January, inclusive, or by the December water or air temperatures on the middle Norwegian coast.[10] The summer temperatures in all the Baltic region are indicated by the winter temperatures of the water about Iceland; and the general character of the April to September rainfall at Berlin, at least, is indicated by the Thorshavn rainfall of the preceding January to March.[11]

Expressed in terms of the Pacific region, these correlations would be as follows: The departures of the strength of the trade wind from the normal at Hawaii during the period May to October (perhaps earlier) may indicate a departure of the same sign in British Colombia during the months December to February following. The pressure gradient between Seattle and Dutch Harbor, September to January, inclusive, or the December air or water temperatures on the coast of southern Alaska when compared with the corresponding values of the year before may give a direct indication of the coming February to March and March to April temperatures relative to those of the same periods of the year before, which will probably have a chance of verification greater than 80 per cent in the region west of the continental divide and north of the forty-second parallel. Finally, the winter water temperatures at Dutch Harbor, and the January to March rainfall on the south Alaskan coast may give for the following summer a direct indication of the temperature and rainfall, respectively, for British Columbia and Washington.

These are, necessarily, rather generalized weather indications; and in themselves may not be of much use. They are, however, convenient as starting points for the many years of investigation which lie ahead of us to determine what the meteorological conditions of the North Pacific are, and how they may be used for making seasonal forecasts for the bordering lands, and with the help of Atlantic conditions, perhaps for the whole of North America.

[8] Journ. Meteorological Soc. of Japan, December, 1915, May and June, 1917; also, M. W. R., 1916, **44**: 17-21, 238-240; 1917, **45**: 299-300, 535-538.

[9] "On the relation between the summer changes of the North Atlantic trade winds and winter temperature in Europe." Proc. Amsterdam Roy. Acad. of Sci., vol. 18, 1916, pp. 1435-1448.

[10] W. Meinardus "Ueber einige meteorologische Beziehungen zwischen dem Nordatlantischen Ozean and Europe im Winterhalbjahr." Met. Zeits. 1898, 2 pl., pp. 85-104.

[11] H. H. Hildebrandsson "Quelques recherches sur les centres d'action de l'atmosphere." V. (last). Kungl. Svenska. Vetenskapsakad. Handl. Bd. 51, No. 8, 1914, 16 pp., 13 pl.

OCEAN TEMPERATURES AND SEASONAL WEATHER IN SOUTHERN CALIFORNIA.

By WM. E. RITTER and GEO. F. MCEWEN.

(Extracts from open letter, dated La Jolla, Cal., Nov. 9, 1918.)

So much does the well-being of the people of California and the whole western United States depend on the amount of precipitation and its time of occurrence each season, that even small, if trustworthy, [advance] indications would be valuable.

The researches on the ocean water off the coast of Southern California prosecuted by the Scripps Institution during the last 10 years, coupled with United States Weather Bureau records for the same time, bring to light somewhat suggestive facts.

Stated very briefly, they are these: During July, August, September, and October, 1917, the temperature of the sea at the institution averaged about 5° F. higher than for the same months of the preceding nine years, and the force of the northwest ocean wind for the same time was about 20 to 30 per cent below the average.

These exceptional conditions of water and wind were followed, as is well known, by exceptional weather conditions of the ensuing winter months. There was almost no rain until January, 1918, and the total precipitation was low for all California.

The conditions of sea and wind for summer and fall months of 1918 have repeated in essential features the conditions of those months for 1917.

As to the character of the data, there can be no question so far as concerns the sea temperatures at La Jolla for the period of February, 1916, to the present (November, 1918). Six temperatures a day, distributed evenly through the 24 hours, every day in the year except Sundays, are taken at the outer end of the institution pier; that is, where conditions are almost typically oceanic. In addition to this extensive and systematic series of temperatures many are taken at numerous stations near shore, and offshore to a distance of 75 to 100 miles from Point Conception to far south of the United States-Mexico boundary line. For the time previous to the completion and utilization of the pier, all temperature observations were of the distributed, intermittent kind, though in the aggregate large numbers were made.*

The defectiveness of the data in this case is the small number of years and the narrow area over which the observations extend. To give such data high predictive value, they would have to be extended over many years and over a far larger portion of the ocean.

As to the question of whether there are known cases elsewhere of connection between peculiar weather conditions on land and peculiar conditions of the ocean, it is to be said that while knowledge in this field is exceedingly meager, some of what we do possess indicates strongly the existence of such connections, and that investigations carried on long enough and widely enough will make possible seasonal and long range weather forecasting on the basis of a combination of atmospheric and oceanic observations much as daily forecasts are now made from observations on the atmosphere alone.[1]

* Cf. Summary and interpretation of hydrographic observations made by the Scripps Institution for Biological Research of the Univ. of California, 1908-1915. Univ. of Cal. Pubs. in Zool., Dec. 6, 1916, v. **15**: 255-356, pls. 1-38.—Ed.

[1] Those who would like further information relative to oceanic conditions and their relation to the weather will find a popular treatment of these subjects in Bull. No. 7, of the Scripps Institution for Biological Research of the University of California, at La Jolla, Cal., by George F. McEwen, oceanographer, entitled: "Oceanic Circulation and Its Bearing Upon Attempts to Make Seasonal Weather Forecasts: a Sketch of Observational Methods and Explanations." The paper is now in the press and will soon be ready for distribution by the Scripps Institution.

KING ISLAND WEATHER:

SEASONAL ABNORMALITIES IN SOUTHERN AUSTRALIA.

By C. RICHARDSON.

[Reprinted from "The Mercury," Hobart, Tasmania, Oct. 19, 1918.]

From January 1 to August 31 in the present year the local rainfall was 26.83 inches. In the same period last year 29 inches were recorded.

Of course, the practical views of seasons taken by farmers or others whose avocations are influenced to a great extent by the weather is almost wholly confined to one factor—the total quantity of rainfall for a season or a year. Although it would certainly seem a very practical way, nothing, however, could be more deceptive or misleading. Ten inches of rain in a normal season is far more satisfactory than 20 inches in an abnormal season. * * * In normal winter seasons in these latitudes there is an almost continuous belt of rainy and stormy conditions, having a mean or average drift (sailors' word) from west to east. In this belt "whirls" or storms of cyclonic formation occur. The dimensions of such disturbances vary. Their approach from the westward is first indicated by northeasterly to north winds, and as the atmospheric "trough" approaches so the mercury descends the barometer tube. The trough contains most of the rain, hail, etc. After the passage of the "center" over any point of observation in its track the winds become SW. to S.; and finally SE. winds extend a considerable distance to the westward, and fine weather prevails for a time. Upon occasions when these cyclonic disturbances cover a comparatively small area the "drift" weather follows closely in their wake. Not infrequently its elements pass eastward in the middle stratum of atmosphere or, in other words, overlap the rear winds of the preceding disturbance; hence the observation of clouds traveling eastward and westward simultaneously. A few years ago these separate disturbances followed one another for some time about every five or six days. They were really troughs traveling eastward within pressure gradients, often described as a trough of atmosphere.

In the present year the comparatively less rainfall in this locality was * * * [associated with] a bank of atmosphere that maintained itself with marked persistency for an exceptionally lengthy period. Its position was approximately from NW. to SE. The [apparent] effect of such a bank or long range of high pressure was to ward off or deflect the elements coming from the westward, hence the smaller quantity of rainfall in King Island. The position of this bank of high pressure in a normal winter is approximately west-east, and as a consequence the march of the weather in such seasons is approximately in a similar direction when directional variations due to thermal effects are eliminated in the calculations.

The departure from normal conditions is when the bank in question takes up an approximately NW.-SE. position. The effects of the alteration are very noticeable not only in the season in which the phenomenon occurs, but also in the succeeding seasons up to the end of autumn, which may aptly be described as "the end of the meteorological year."

The belt of rain and gales in the Southern Ocean is popularly known as the "Roaring Forties" on account of its being on the average confined to the 40° latitude. When this belt maintains a regular march from west to east, Victoria, King Island and Tasmania enjoy a normal winter and spring season, but from one cause or another the belt does not always traverse such [a] course. In some winters, and for a number of winters in approximate succession, it appears to curve northward somewhere to the eastward of St. Paul's Island.

The detour invariably causes a [strong] east wind * * *. During these operations fine weather prevails in Victoria, Bass Strait, and Tasmania. Upon some occasions the belt maintains its continuity, and regains its easting by passing over the SW. portion of West Australia in a NW.-SE. direction. Upon other occasions the belt is severed in the extension. The curvature subsequently appears to be represented by the lay of a high-pressure bank lying approximately NW.-SE. In places pressure in the bank varies, and as a consequence the elements of the belt [apparently] take advantage of the opening to regain their easting. The position and stability of the bank of high pressure has a very important bearing on the climate of Australia. A majority of the NW. winds at Cape Leeuwin during the winter months is reliable evidence of one of the effects of a curvature of the Southern Ocean rain belt.

Another feature as the result of the curvature is that separate, or cyclonic, disturbances traverse a similar course, and as a consequence carry with them a considerable amount of comparatively high temperature * * *.

As to what is the actual or primary cause of these curvatures is not of very great importance, seeing that they can not be prevented by man, but in view of their close relation to drought or droughty conditions in the Commonwealth an extensive, systematic, and whole-hearted investigation of the phenomenon may be the means of enabling the Commonwealth meteorologist to gain a better knowledge of what transpires in the South Indian and Indian Ocean. * * *

ADDITIONAL NOTE.

[Dated: Currie, King Island, Tasmania, Oct. 31, 1918.]

I may mention that locally in discussing the seasons, or rainfall, in years in which the curvatures [of the path usually followed by cyclones] occur, the words "dumbbell years" are used, which means that the rainfall resembles the same [when represented graphically by successive parallel lines the lengths of which are proportional to the amounts of rain each day, and the centers of which are on the same straight line]. In other words the rainfall from the commencement of autumn is normal, then a comparatively mild winter follows, the latter portion of August is mild, and September even quite summery, following which about eight weeks of wintry conditions prevail. In the latter, temperature appears to keep the cloud at an altitude that deprives us of the *quantity* of rain we would get if the resumption of the eastward march were from a point further south of NW. or WNW., or on a west-east course.

I have recently read an interesting manuscript article on the subject of rainfall, written by an old Antarctic whaler, in which he attributes variation of rainfall in Australia and Tasmania to extension of icebergs, the latter being depicted in his diagram as being carried northward, or toward the South Indian Ocean, by a polar current. The course of the current and extension

coincidentally correspond to the curvature * * * [of cyclone paths referred to previously.] * * * I had nine years study of it [in looking over the logs of eastward-bound vessels].

These "dumb-bell winters" are very provoking to the agriculturist on account of the mock spring they cause. People sow accordingly, and just about the time the plants are above the ground (late September or the first week of October) about eight weeks or two months wintry weather sets in, causing no end of trouble. Our politicians gape aghast when they see the cost of observing and recording "effects" (the money expended in trying to get at the cause or causes is infinitesimal) and as a consequence they have the Meteorological Department "set" as "useless," "farcical," "waste of money," etc.

Every year the wind vane at Cape Leeuwin lighthouse tells the Australian world its part of the story with the greatest reliability, but year after year it passes unheeded, not understood, etc. We here, on this bit of land, 40 by 16 [miles], take no interest in statistics of the past. However, is nothing deducible from those statistics? If not, where does the value come in?

What is needed in Australia is a solar observatory, and some of the thousands of pounds sterling that are spent annually in the compilation of data could be devoted with far greater benefit to the Australian people to such an observatory, for it is mainly by the existence or otherwise of the curvature I refer to that so many millions of Australian money are affected.

It seems absurd to think that the Government meteorologist in Melbourne can not inform the people early in June of such curvature when the masters of vessels tell him that their vessel emerged from a dense wall or mountain of coarse weather near St. Pauls and steamed for 8 to 10 days through an easterly gale in comparatively clear weather—what is that but the plainest evidence of the curvature of the usual belt northward—for the same masters visit King Island and they will find the same or similar conditions recorded? * * * In years to come perhaps some one will succeed in getting at the cause of the variation [icebergs, solar variations?] and thus render a great service to thousands of helpless beings who are from time to time ruined by the effects of drought and broken winters too.—*C. Richardson.*

THE MARINE OBSERVER'S HANDBOOK.[1]

(Abstract.)

The second edition of The Marine Observer's Handbook, the standard work on marine meteorology, follows closely the lines of the first edition, issued in 1915. There is a foreword by Sir Napier Shaw, until recently director of the meteorological office, and a brief history of the office. Part I of the handbook is devoted to a description of the instruments and methods of observation required for keeping the meteorological record, or log. Part II deals with observations of wind, sea disturbance, clouds, weather and optical phenomena, including a comprehensive treatment of the subject of waves and swell. Part III comprises instructions for keeping the meteorological records. In the appendix are illustrations of cloud forms, with a graphic guide to their recognition, meteorological tables, instructions for transmitting weather reports from ships at sea by radio telegraphy, and a list of publications, for the most part issued by the Meteorological Committee and its predecessors.—*F. G. Tingley.*

[1] 2d ed., Meteorological Office, London, 1918, 142 pp., 23 figs., 7 plates. Price 3s. 6d., net.

DEFINITIONS OF "MEAN," "AVERAGE," AND "NORMAL."

(Dictionary definitions and contributions from C. F. Marvin, A. J. Henry, H. C. Frankenfield, C. F. Talman, J. Warren Smith, P. C. Day, and Cl. Abbe, jr.)

Compiled by C. F. BROOKS.

[Dated Washington, D. C., Jan. 4, 1919.]

Dictionaries make little or no distinction between the meanings of the three terms *mean, average,* and *normal;* yet in meteorological usage, *normal* has a meaning fairly distinct from *mean* or *average*. Let us consider prevailing definitions of each term; and attempt to arrive at some generalities which should govern the use of each in meteorological statistics.

MEAN.

In Webster's Dictionary[1] we find: "*Mean.* a. 4. *Math.* Average; having an intermediate value between two extremes, or between the several successive values of a variable quantity during one cycle of variation, such that were they all equal, the mean would be their common value. * * * [As a noun]. Usually, unless otherwise specified, it is the one simple average (called arithmetical mean) formed by adding the quantities together in any order and dividing by their number." A more detailed discussion is to be found in the Century Dictionary and Cyclopedia (New York, 1911).

AVERAGE.

From Webster's Dictionary we have the following definition: "*Average.* n. 5. A mean proportion, medial sum, or quantity, made out of unequal sums or quantities; an arithmetical mean." Murray's Dictionary[2] says that an *average* is the distribution of the aggregate inequalities of a series of things among all members of the series, so as to equalize them and ascertain their common, or mean, quantity, etc., when so treated; the determination or statement of an arithmetical mean; a medial estimate. The Century Dictionary gives: "*Average* II a. 1. Equal in amount to the sum of all the particular quantities of the same sort divided by the number of them; as the average yield of wheat to the acre; the average price of anything for a year; hence 2. of medium character, quality, etc.; midway between extremes; ordinary."

AVERAGE AS DISTINGUISHED FROM MEAN.

Marriott in "Hints to Meteorological Observers" (6th ed., 1906) says that the arithmetical average or mean is the sum of all values forming the series of figures under consideration, divided by their number; and that *average* is the term used for results extending over a long period, while *mean* is used for short periods, e. g., a day, month, or year. Thus we might speak of the *mean* temperature of December, 1918, but of the *average* December temperature during the period, 1899–1918.

Dr. H. R. Mill, director of the British Rainfall organization, says (M. W. R., January, 1915, **43**:42): "For convenience I use the term *mean* as indicating the sum of any

[1] Webster's New International Dictionary, Springfield, Mass., 1911.
[2] Sir James A. H. Murray, A New English Dictionary on Historical Principles, etc. Oxford, 1908.

number of figures divided by that number, reserving the word *average* for the mean of a number of figures representing values in order of time. Thus the mean of 30 annual rainfall values is spoken of as the average rainfall for 30 years. The mean of a number of uniformly distributed figures, representing the distribution of rainfall in space I speak of as the general rainfall of the area concerned; thus the mean depth of rainfall over England for any day, month, or year is the *general rainfall* of England for that particular day, month, or year. The mean of the general rainfall of England for 30 years is expressed as the *average general rainfall* of England for 30 years."

The Weather Bureau believes the usage of *general* and *general average* as defined by Dr. Mill is desirable; but prefers not to prescribe nor limit the use of these terms, in view of the varied nature of the publications of the Bureau and the personal customs of authors.

Mathematically, the quantities to which the terms *mean, average*, and *normal* are applied in dealing with statistical data are essentially the same, namely the quotient found by dividing the sum of a series of values by the number of values. In ordinary usage there is no essential difference in the significance of *average* and *mean*. In general, it is not of much consequence whether *mean* or *average* is used since the context will usually show what is meant. It is evident, however, that both here and in Great Britain, meteorologists use *mean* in discussing current data, and *average* in discussing the data of a number of years, especially in dealing with areas.

NORMAL.

In Webster's Dictionary we find: "*Normal*. 2. The ordinary or usual condition, degree, quantity, or the like; average; mean." Murray's Dictionary gives: "*Normal*. 3. Physics. The average or mean value of observed quantities. 4. The usual state or condition." The Century Dictionary says: "*Normal* I a. 1. According to a rule, principle, or norm; conforming to established law, order, habit, or usage; conforming with a certain type or standard; not abnormal; regular; natural."

Regarding the question of *normals* in Weather Bureau records, an inquiring correspondent was answered in part as follows: "*Normals* are the averages of all observations available from the beginning of the record at the respective stations to the time the values were completed and put in operation. * * * As a rule normals are not prepared for stations having a record of less than 10 years." (M. W. R., March, 1907, **35:** 125.) Thus, the word *normal* is used rather too broadly to represent averages of a period of 20 years and even less. Strictly speaking, "our idea of a normal implies, first, that it is the average of a great number, and second, that it contains within itself nothing abnormal—that is to say, that abnormal events have so counteracted each other as not to injuriously affect the average of many values." (Cleveland Abbe, M. W. R., 1895, **23:** 294.)

Prof. C. F. Marvin gives another statement of the meaning of *normal* in meteorology and how it may be obtained:

"While the word *normal* must properly be considered to signify the mean or arithmetical average of a very large number of homogeneous observations, it must nevertheless be recognized that an acceptable value of a normal may be deduced from a shorter series of homogeneous observations by a proper mathematical process. Such a process aims to secure values toward which the observed conditions, as expressed by the average thereof, tend continually to approach as the record becomes longer and longer.

"It may be quite possible, by properly analyzing the records of temperatures of all, or many, stations of the United States, for example, to formulate an equation showing the normal annual or diurnal march of temperature as a mathematical function of a given form. We are greatly assisted in such an effort if perchance we may know of a rational equation expressing the relations between the element in question and the lapse of time. In meteorology this is unfortunately rarely the case, and too often it is necessary to adopt such purely empirical equations as, for example, the well-known Fourier series. The values obtained by such an analysis give us, possibly, hourly, daily, monthly, seasonal, annual, and other values that may be truly characterized as normals and toward which it is believed the average of a long series of observations will more and more closely approach as the length of record increases. Clearly, however, such normals might differ quite considerably from the averages of 20, 30, 50, or 100 years of records.

"I am doubtful if it would be advisable to specify any number of years of data that would be assumed to be sufficient to justify the use of the word *normal*, but rather leave this a somewhat indefinite interval. Notwithstanding its vagueness of definition the word *normal* is a convenient one to distinguish the average of a few results from the mean of a considerable number, or even of the greatest number of values available."

A meteorological or climatic normal is, at best, a makeshift, because the conception of a normal in its most exact sense implies a stability of climate which may not exist. It is inconsistent with the idea of long-period fluctuations of climate that have occurred—certainly in the course of ages, and probably within historic times. The length of record necessary for practical purposes in any case varies greatly with the location of the station, the element considered, and the interval (day, month, year, etc.).

AVERAGE AND NORMAL.

Average and *normal* appear closely associated, and it is thought they refer generally to the same subject save that *average* might be used when there is more or less uncertainty as to whether the number of terms is sufficient to give a result that would not be appreciably changed by the addition of another, within the probable range of the element. An additional word, very generally necessary, will give the key to the interpretation to be placed upon the term and this very generally appears when they are used.

The fact that so-called normals are more or less close approximations to ideal values is shown by the fact that we often speak of "good normals," "poor normals," "provisional normals," etc. While meteorologists are not misled by the conventional use of this term, it is likely to mislead others. We can not discontinue, however, the use of the word *normal* in our climatological publications, even though, as is obvious, we have few records continued long enough to establish true normals. The "departures from normal," which are really departures from quasi-normals, have nevertheless a very practical value.

We conclude, therefore, that while normals are also means and averages, we should not loosely substitute either of these last two words for *normal* or the reverse any more than we would speak of a *dog* as a *horse* because it was hitched to a cart.

FROST AND THE GROWING SEASON.[1]

By William Gardner Reed.

(Review by C. F. Brooks.)

The appearance of a folio of colored maps marks the final outcome of an extensive investigation of the dates of killing frost in the United States initiated by Mr. O. E. Baker about six years ago. In 1913, 1914, and the first half of 1915, the Weather Bureau section centers and Central Office, and the Office of Farm Management were engaged in collecting and editing critically all the frost data available. The records for the period 1895–1914 were selected for the sake of homogeneity. In the latter half of 1915 these data from about 4,000 stations were mapped and the long records from about 600 stations were subjected to mathematical analysis. The results of this study are presented in detail by Mr. Reed in the Proceedings of the Second Pan American Scientific Congress (vol. **2**, pp. 593–631, tables, 13 figs.). In this paper he describes not only the distribution of frost dates in the United States, but also presents tables of selected records and the details of the mathematical procedure used to obtain dates when the risk from spring or fall frost would be at a specified value. Several short papers, principally on the mathematics of the frost risk in farming, were published in 1916 by Mr. Reed independently, or jointly with Mr. H. R. Tolley (mathematician) and Prof. W. J. Spillman (then chief, Office of Farm Management).[2] Some of the frost maps have been published and briefly discussed in the National Weather and Crop Bulletin during the past three years.

In spite of these previous discussions, the publication under review is in no sense a repeater. The frost data of the United States are presented in detail by pleasing colored maps on a relief base; and selected records are strikingly portrayed in graphical form. The simple and well-written discussion goes into the geographical and agricultural aspects of frost and the growing season in the United States.

The study deals only with the occurrence of "killing frost" or its approximate equivalent, a temperature of 32° F. or lower. Thus we are concerned with the dates when widespread damage is done to vegetation by the cold and not with the formation of frost deposits. The last killing frost in spring limits the start of vegetation, and the first killing frost in autumn puts an end to most vegetative activity unless plants have already prepared for the winter. It is of considerable interest to the farmer to know when these critical frosts are most likely to occur, and to know just when a particular killing frost will come. From the weather map and from local signs, such forecasts are made. To illustrate killing frost weather types, 10 weather maps are reproduced. Warnings of killing frost are, however, of little use unless the farmer is prepared to meet them, either by actually protecting his endangered crops, or by having a surplus from previous successful years sufficient to cover his losses.

Latitude and altitude are of primary importance in determining the months of occurrence of killing frost. Relative altitude in rough country is for some localities more important than actual elevation above sea level. This frostiness of valley bottoms made it very difficult to draw the frost date lines in most of the highland regions of the United States.

"The most noteworthy fact regarding these critical frost dates is their extreme irregularity." Nevertheless, by arithmetical averaging it is easy to get dates before and after which crops will be subject to killing frosts in about half the years. The maps of the average dates of last killing frost in spring and first killing frost in fall show the frost lines running mostly east and west in the eastern United States, bending northward near large bodies of water and over large valleys, and southward over the highlands. In the western United States, topography is the most important control other than that exerted west of the Sierra Nevada—Cascades by the Pacific Ocean. The map of the average "growing season" has much the same characteristics. In fact, all three differ only in details.

As corner inserts of these three double-page maps are small maps showing the areas covered by each general "wave" of last killing frost in spring and first in fall. A given frost may occur over a large area on one date, and another some time later over another region not coextensive with the first. Nine such overlappings are marked on the spring map and 8 on the autumn.

Variations in the dates of spring or fall frost by 10 days or more from the average are common (i. e., over 5 times in 20), where frosts may not occur every spring or fall, as along the Gulf coast, and where the effect of topography varies with the type of weather as in the mountainous region of the West. The maps of security from killing frost show the dates on which the chance of killing frost in spring (autumn) falls (rises) to 10 per cent. These maps are practically the same as the average date maps, but the dates are 10 to 30 days later in spring and earlier in fall. "The areas in which the chance of spring [(autumn)] frost is greater than 10 per cent on June 1 [(Sept. 1)] include the region along the northern boundary of the United States, elevated areas in the Appalachian Mountains, and the greater part of the higher altitudes of the West."

The maps of the growing season are the most important from the agricultural point of view. The large double-page map of the average length of the "growing season" shows detailed lines for every 10 days in the eastern United States and for every 30 days from the Rockies westward. "Throughout most of Florida, along the coast of the Gulf of Mexico, and in favored localities in Arizona and California, the average season without killing frost is more than 260 days. Along the northern margin of the cotton belt it is about 200 days, along the northern margin of the corn belt from 140 to 150 days, in northern Maine and northern Minnesota, where hay, potatoes, oats and barley are the principal crops, it is about 100 days, and in the higher regions of the West it is less than 90 days." If a farmer were to raise crops requiring the average length of the growing season to mature he would not get a harvest in more than a third of the years.

The map showing the available growing season in four-fifths of the years shows a period 15 to 50 days shorter than the average "growing season." "In the region having 90 days or less without frost in four years out of five, general farming is limited largely to small grains, grasses, and potatoes; and, in general, the area is much the same as that in which the average period without killing frost is less than 90 days, although, of course, somewhat greater in extent. The longest growing season is found in the States bordering the Gulf of Mexico, in southern Arizona, and portions of California. The safe growing season in the eastern United States varies from about 240 days along the Gulf of Mexico to 100

[1] Atlas of American Agriculture, Advance sheets, 2, pt. II, sec. 1, issued, 1918. 48 by 34 cm. 12 pp., 12 colored maps, 10 weather maps, 10 graphs. Selected bibliography.

NOTE.—The rest of the climatic section has been ready for publication for some time and may reasonably be expected to appear in 1919.—EDITOR.

[2] Geogr. Rev., vol. 2, pp. 48–53; M. W. R. **44**: 509–512, 197–200.

days or less in Minnesota and the Dakotas, and 90 days or less in parts of the Appalachian Mountains and the higher altitudes in New York and New England. In the more elevated regions of the West the safe season is less than 90 days. This map represents, in general, the number of days expected to be available for the growth of crops in a sufficiently large proportion of the years to enable the organization of farm enterprises on that basis with a reasonable chance of success." In the selection of suitable planting dates, the chance of spring frost damage, the advantages of maturity for early markets, and the length of the growing period of the crop must all be considered. Greater risk can be taken with some crops than with others.

HOURLY DURATION OF PRECIPITATION AT PHILADELPHIA.

By GEORGE W. MINDLING.

[Dated: Weather Bureau Office, Philadelphia, Pa., Dec. 19, 1918.]

What information can we give to business men as to the amount of time likely to be lost at different times of the day at various seasons of the year on account of stormy weather? What facts of diurnal distribution of rainy weather can be brought out that may prove helpful in the preparation of either State or local forecasts? Is there a diurnal periodicity in the occurrence of rainfall such that we may depend on certain parts of the day to be more likely to give rain than others, or, more particularly, a greater duration of rainfall than others?

If the periodicity is sufficiently marked, a knowledge of its character ought to enable one to say with some assurance at what hours it will be most likely to rain, especially under conditions of somewhat unsettled weather when the prospects of precipitation are doubtful. Also such knowledge should aid in enabling one to say when a storm of moderate severity may be expected to abate.

The total duration of precipitation in Philadelphia has been found to average 928 hours per year, which is equivalent to more than five weeks of continuous precipitation. The duration of precipitation is nearly as great or greater in most of our highly developed industrial centers, especially those surrounding the Great Lakes and in the northeastern part of the country, as may reasonably be inferred from the average annual number of days with 0.01 inch or more of precipitation. Such averages for the ten years beginning with 1907 are as follows: Philadelphia, 122; Albany, 127; Boston, 114; Buffalo, 163; Chicago, 123; Cincinnati, 127; Detroit, 136; New York, 121; Pittsburgh, 149. Obviously, then, if the diurnal distribution of precipitation is not too haphazard, it must be deserving of careful study, especially in regions where some form of precipitation is occuring more than one-tenth of the time, as is true in Philadelphia.

It could not be out of place in connection with a study of this kind, to make some references to studies of the average amount and frequency of precipitation for the different hours of night and day.

1. The pronounced diurnal period in the relative amounts and frequency of rainfall in tropical countries suggested to Dr. Fassig a study of these matters in his work on "The Climate and Weather of Baltimore." (See Maryland Weather Service, Vol. II, pp. 165–170.)

In his studies of the average hourly amounts of precipitation for a ten-year period, he found the winter and spring months characterized by a rather uniform distribution of precipitation throughout night and day, while summer rains were generally light in the forenoon, increasing rapidly about the middle of the day and more slowly in the afternoon with a maximum about 5 p. m. The uniformity observed in winter and spring he attributed to the general dependence of precipitation in those seasons on the "more or less regular succession of the cyclonic disturbances of the middle latitudes whose eastward progress is but slightly, if at all, affected by the diurnal variations of temperature and pressure." The influence of thunderstorms was distinctly seen in the large average amounts of rainfall for summer afternoons.

His investigation of the hourly frequency of precipitation was based on compilations of the total number of days in each month for 10 years on which precipitation occurred in the various 24-hour periods. Thus, between 4 p. m. and 5 p. m. in the month of March precipitation occurred on 61 days during the 10 years. This was the hour of the greatest frequency. The hour of least frequency was from 4 a. m. to 5 a. m. in August, the total number of days with precipitation being only 9. For the year as a whole, the average frequency was least about 2 a. m. to 4 a. m. and greatest about 4 p. m. to 6 p. m. The July curve exhibited the strongest periodicity; that of March, the greatest uniformity.

2. Similar studies of Chicago records were made by Cox and Armington. (See Weather and Climate of Chicago, pp. 203–208.) Owing to the severity of the Chicago winter climate, which makes continual use of the tipping-bucket rain gage impossible, it was necessary to limit the study of hourly amounts of precipitation to the period of April to October, inclusive. The results showed considerably less symmetry than those obtained at Baltimore, yet there was, "in general, a relation to be seen between the times of greatest hourly rainfall and the times of occurrence of thunderstorms."

Much greater regularity was found in the mean hourly frequency of precipitation, but the rather distinct early morning minimum and afternoon maximum observed at Baltimore were hardly discernible at Chicago. In other respects there was similarity in the conditions observed at the two places.

3. Records made at a number of places in the interior of Europe show greatest frequency of precipitation in the morning hours in winter, in afternoon hours in summer. The diurnal variation in amount is discussed by Hann (Lehrbuch der Meteorologie, 3d ed., p. 343 and following) somewhat as follows:

> The diurnal variation in precipitation is a rather complicated phenomenon. In the course of the day there occur in most places two maxima and minima, frequently three. Not infrequently it is scarcely possible to recognize any sort of regular trend in the hourly averages. Studies of available records do not warrant making a concise statement of the general characteristics of diurnal variation in intensity of rainfall; one can only present some of the more distinct types. * * * In the continental type of the temperate zone, there is a principal maximum in the afternoon and a lesser maximum in the early morning hours, while the prominent minimum occurs between midnight and 4 a. m., and a secondary minimum between 8 a. m. and noon. In the oceanic type, the times of principal maxima and minima are the reverse of those in the continental type.

4. Kincer has shown that during the season of April to September, inclusive, there is a marked predominance of daytime precipitation over nighttime precipitation in the States along the Gulf of Mexico as far west as Galveston, Tex., and an equally pronounced excess of nighttime precipitation in the Central Plains region. (See vol. 44 of this REVIEW for 1916, pp. 628–633.) Whether considered with respect to the amount, frequency, or total duration of the precipitation, the dominance of daytime rains in the

southeast and of nighttime rains in the Central Plains was always apparent in about the same degree.

The influence of "atmospheric convection during the warmer portions of the day, a characteristic of tropical and semitropical rainfall conditions" was readily seen in the preponderance of daytime precipitation in the Gulf coast region, but no fitting meteorological explanation could be offered for the opposite condition characteristic of the Plains region.

The happy provision of nature, however, that gave the bulk of a rather stinted rainfall to our central grain-producing sections not only within the limits of the growing season, but also mostly at night, when the loss by evaporation is least, was admirably brought to light.

In considering the economic significance of the time of occurrence of rainfall, Kincer very aptly gave attention to the actual number of hours during which rain occurred by day and by night at selected stations representing the regions of opposite type as well as the region of intermediate type between. He found the duration in hours to exhibit variations corresponding closely to the variations in amount and in frequency. Where the bulk of precipitation occurred at night, the average number of hours' duration of rainfall at night was correspondingly greater than in the daytime; also the number of occurrences at night exceeded that in the daytime, the reverse of these conditions being true in the regions of predominating daytime rainfall.

From the foregoing, one might suppose that the hourly frequency data, such as have been compiled for Baltimore and Chicago, would throw some light on the relative duration of precipitation for the different hour periods of all parts of day and night. In particular, one might expect the hourly frequency averages at Baltimore to show variations corresponding more or less closely to the hourly duration averages at Philadelphia. But careful comparison fails to indicate any resemblance worth mentioning, so far as diurnal variations are concerned. It is true that the two sets of data have, in common, maximum values in midwinter and minimum values in midsummer with much more striking variations for any given hour from season to season than exist in any season between one hour and any other.

In the discussions of the closely related subjects referred to above, numerous facts are brought to light showing the varying effect of differing local conditions on diurnal variations in rainfall with respect to amount and frequency. Obviously, the only dependable method is to establish the conditions for each locality by a study of its own records. Even within the realms of the middle latitude continental type, differences in elevation and differences in location with respect to mountain ranges, lakes, and storm tracks, are very likely to produce different aspects in the diurnal distribution of precipitation.

In the opinion of the writer, the data of average hourly duration are more valuable than those of average hourly frequency, while they are hardly any more difficult to compile. The latter possibly have no less meteorological significance than the former, but they do not necessarily indicate the amount of time that is likely to be lost in outdoor operations, which is the prime consideration from most economic points of view. Moreover, it is a matter that is receiving a rapidly increasing measure of attention in the business world. At any rate, an increase of attention to this matter has been very much in evidence in Philadelphia in connection with the intensified industrial activities of the last two or three years. It finally led to the writer to undertake the compilation of the length of time precipitation has occurred in Philadelphia in each hour of the day and night. Up to this time it has been possible to summarize only a 10-year period of records in this project.

While the addition of further records would, of course, modify results to some extent, it is believed that the averages already obtained and the characteristics of the different seasons thereby revealed are of sufficient value to warrant publication without waiting to make a more exhaustive investigation. The adequacy of the results has been tested in two ways. First, by taking averages for 8 or 9 years and comparing these with the 10-year averages. Second, by assuming two or three succeeding years to give results the same as those of a corresponding number of years for which compilations had been made and then determining a 12- or 13-year average. Particular attention has been given to the effect upon the highest and lowest averages in a given month resulting from the addition of years in which the values for the corresponding hours were of the opposite extreme. It is found that in extreme cases the monthly average for a given hour period may change by 0.2 to 0.4 hour with the addition of from one to three years with unusual conditions prevailing. This means that, while investigation of a period longer than 10 years would yield somewhat smoother curves, the time of occurrence of maximum and minimum, the general trend of the curve between daytime and nighttime or between forenoon and afternoon, and the variations in duration of precipitation from month to month are indicated in the appended graphs with fairly close approximation.

The tables and graphs herewith merely summarize the results obtained, and these will be more readily understood if a brief description of the tabulation originally involved is introduced.

In the first place, it was necessary to prepare 120 tables, one for each month in the 10-year period. Each of these tables consisted of 24 columns, representing the 24 hours, midnight to midnight, and an additional column for daily totals. A horizontal line in the table was used for each day on which precipitation occurred, and an additional line for the monthly sums. When the table was completed, one was able to state, for example, that rain fell during 0.1 hour between 1 p. m. and 2 p. m. on August 23, 1912; that the total duration of rainfall for the month between those hours was 2.1 hours; that in the same month no rain occurred between the hours of 6 a. m. and 8 a. m.; and that the total duration of rainfall during the whole month was 33 hours.

Secondly, the monthly sums as obtained in the 120 tables were transferred to 12 summary tables, one for each of the 12 calendar months, which were similar in form to the monthly tables, except that one line was used for each of the 10 years and additional lines for the sums and means.

To illustrate, the January summary showed for that month a total duration of precipitation for the 10 years ranging from 55.8 hours between 10 p. m. and 11 p. m. to 43.4 hours between 5 p. m. and 6 p. m. This is equivalent to an average daily duration of 10.8 minutes between 10 p. m. and 11 p. m., and of 8.4 minutes between 5 p. m. and 6 p. m. In the different years the total duration of precipitation ranged from 167.5 hours in 1910 to 68.4 hours in 1908, the average being 119.1 hours.

As the number of days is not the same in all months, it is necessary to reduce results to a common period in order to permit strict comparison of conditions in one month with those in any other. Therefore, in the accompanying table, the monthly values for February

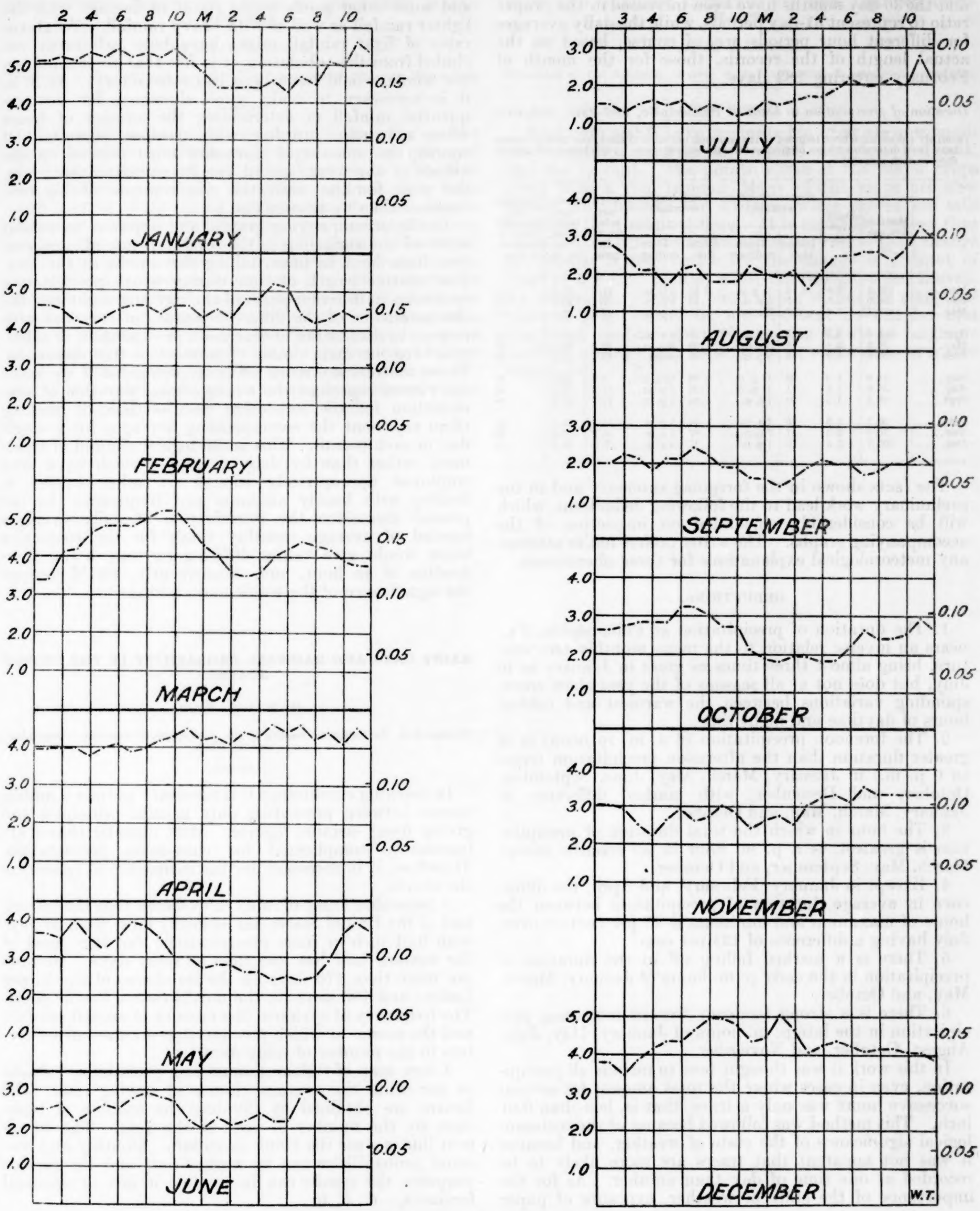

FIG. 1.—Hourly duration of rainfall by months at Philadelphia.

Relative length of the time during which precipitation has occurred at Philadelphia in each of the 24-hour periods in each of the 12 months. Actual 10-year averages for the several months have been reduced to a common 31-day period. For example, the total average duration of precipitation in January between midnight and 1 a. m. is 5.1 hours as shown by the dot in black in the 1 a. m. position. (The scale on the right of each graph represents the hours per day.—*Ed.*)

and the 30-day months have been increased in the proper ratio to represent 31-day periods, while the daily averages for different hour periods are, of course, based on the actual length of the records, those for the month of February covering 283 days.

Duration of precipitation in hours at Philadelphia, 1907–1916, inclusive.

[Monthly values have been reduced to the common period of 31 days, and hourly values have been determined from original results through division by the actual number of days in each month.]

	Monthly average.	Daily average.	Greatest hourly average.		Least hourly average.		Average total, 6 a.m. to noon.	Average total, noon to 6 p.m.	Per cent of monthly total, 6 a.m. to 6 p.m.
			Duration.	Hour ending—	Duration.	Hour ending—			
Jan.	119.1	3.8	0.18	11 p.m.	0.14	6 p.m.	31.0	27.3	50
Feb.	108.0	3.5	.17	5 p.m.	.13	4 a.m.	27.2	28.6	52
Mar.	103.1	3.3	.17	9 a.m.	.11	3 p.m.	29.3	23.1	51
Apr.	101.0	3.3	.15	5 p.m.	.13	4 a.m.	25.1	25.9	51
May	76.0	2.4	.13	3 a.m.	.08	5 p.m.	19.9	15.7	47
June	59.8	1.9	.10	8 p.m.	.07	noon	15.5	13.5	49
July	41.0	1.3	.09	11 p.m.	.04	10 a.m.	8.3	10.6	46
Aug.	54.6	1.8	.11	11 p.m.	.05	3 p.m.	11.8	12.7	45
Sept.	46.5	1.5	.08	7 a.m.	.04	1 p.m.	11.7	10.9	48
Oct.	59.3	1.9	.10	7 a.m.	.06	5 p.m.	15.5	11.4	45
Nov.	70.0	2.3	.11	7 p.m.	.07	4 a.m.	16.0	17.9	48
Dec.	101.7	3.3	.16	1 p.m.	.11	2 a.m.	27.8	26.3	53

The facts shown in the foregoing summary and in the preliminary work lead to the following deductions, which will be considerably elucidated on inspection of the accompanying graphs. The writer prefers not to attempt any meteorological explanations for these phenomena.

DEDUCTIONS.

1. The duration of precipitation at Philadelphia, Pa., bears an inverse relation to the mean monthly temperature, being almost three times as great in January as in July, but does not at all seasons of the year show corresponding variations between the warmest and coldest hours of daytime and night time.
2. The forenoon precipitation (6 a. m. to noon) is of greater duration than the afternoon precipitation (noon to 6 p. m.) in January, March, May, June, September, October, and December, with marked difference in January, March, May, and October.
3. The hour in which the total duration of precipitation is greatest, is a p. m. hour in all months except March, May, September, and October.
4. Except in January, February, and April, the difference in average duration of precipitation between the hours of maximum and minimum is 45 per cent or over, July having a difference of 133 per cent.
5. There is a marked falling off in the duration of precipitation in the early p. m. hours of January, March, May, and October.
6. There is a strong tendency toward increasing precipitation in the late p. m. hours of January, May, July, August, October, and November.

In this work it was thought best to include all precipitation, even in cases where the total amount for several successive hours was only a trace, that is, less than 0.01 inch. This method was followed because of the meteorological significance of the state of weather, and because it was not apparent that traces are more likely to be recorded at one time of day than another. As for the importance of the state of weather, exposure of paper and some other goods would result in damage with the lighter rainfall as well as with heavy rainfall. Whatever rates of light rainfall might have been arbitrarily excluded from the tabulation, it is felt that the results, on the whole, would have been less satisfactory. As it is, it is necessary to make some allowance for inconsequential rainfall in determining the number of hours when rain may interfere with outdoor pursuits. Of course, the amount of allowance must depend on the nature of the work, and it can be estimated better by the man familiar with the requirements of his own business than by anyone else.

In the accompanying graphs, the object is to exhibit in detail the variations in the total duration of precipitation from hour to hour, taking the month as the unit. The relative length of time during which precipitation continues in different parts of the day and night and the characteristics of the different seasons of the year with respect to dominance of afternoon precipitation or otherwise, are the main points of interest in this discussion. These matters are more easily apprehended if we make the curves represent the average total duration of precipitation for the respective months than by making them represent the corresponding averages for a single day in each month. This is the logical method of treatment rather than by daily averages, which have been employed appropriately enough by other writers in dealing with hourly amounts and frequency. In the present discussion the introduction of daily averages instead of average monthly totals for the respective hours would give values differing by only a few hundredths of an hour, and, consequently, would destroy the significance of the whole undertaking.

RAINY DAYS AND RAINFALL PROBABILITY IN THE UNITED STATES.

By R. DeC. Ward.

[Presented at the Baltimore meeting of the Association of American Georgraphers, Dec. 28, 1918.]

(Abstract.)

In teaching climatology it is necessary to steer a middle course between presenting only general principles and giving many detailed figures. Most climatic charts are impossibly complicated for class-room presentation. Therefore, it is necessary for the instructor to generalize the charts.

A generalized map of rainy days shows, that the eastern half of the United States has annually more than 80 days with 0.01 inch or more precipitation; and that most of the western half has less than 80 rainy days. Maxima are more than 170 days on the lee shores of the Lower Lakes; and 180 days on the northwestern Pacific coast. The frequency of cyclones, the amount of annual rainfall, and the season at which precipitation occurs—all are factors in the number of rainy days.

A new map of "Mean annual rain probability" shows in per cents the average chance of having rain. The figures are obtained by dividing the number of rainy days by the number of days in the year. The 20-per cent line is near the 100th meridian. Monthly and seasonal probabilities can be worked out; and for various purposes the results can be applied in lieu of seasonal forecasts.—*C. F. B.*

THE ANCIENT PIEDMONT ROUTE OF NORTHERN MESOPOTAMIA.

By ELLEN C. SEMPLE.

[Presented at the Baltimore meeting of the Association of American Geographers, Dec. 28, 1918.]

(Abstract.)

Climate played an important part in making the ancient piedmont route of northern Mesopotamia the principal one between the Orient and the Mediterranean. The Red Sea route, geographically attractive, was relatively little used because of the strong northwest winds which blew in the upper part as if in a funnel between the high-confining walls of the Anatolian and Lybian Plateaus. The northern Mesopotamian route, topographically easy and direct, had, besides, a favorable climate. The winter snows on the mountains yielded water slowly enough to make the small amount of average precipitation (10 inches) sufficient to irrigate valley lands and thus to support a series of disconnected settlements on the piedmont. It was through these towns that the ancient commerce moved; and it is through these towns on the same sites that the present Bagdad Railroad passes.—*C. F. B.*

PAST AND PRESENT CLIMATES OF OUR LEADING CROP PLANTS.

By H. C. COWLES.

[Presented at the Baltimore meeting of the Association of American Geographers, Dec. 27, 1918.]

(Abstract.)

Most crop plants have originated in what are now tropical or subtropical regions; tropical America, Malaysia, and the Levant. The potato alone of the major crops came from a cool region. Many of the crops are now grown only outside the Tropics, while others are still raised in their original zone. It is generally agreed that mutation, or perhaps acclimatization, rather than change of climate, is responsible for the change of habitat of most of our crop plants, while the rest have not moved. An interesting phase of plant origin is that for many the place of origin is by far not the best habitat for that plant. A cold-resistant plant is as likely to originate (though not as likely to survive) in a warm as in a cold region.—*C. F. B.*

SECTION III.—FORECASTS AND WARNINGS.

FORECASTS AND WARNINGS, NOVEMBER, 1918.

By ALFRED J. HENRY, Supervising Forecaster.

[Dated: Weather Bureau, Washington, Dec. 20, 1918.]

Pressure at Midway was considerably above the normal throughout the month except on the 3d, 20th to 23d and again on the 29th and 30th. At Honolulu, on the other hand, pressure was quite uniformly below normal, except for about a week beginning the 12th and ending the 18th.

In Alaska there were sharp alternations from high to low pressure in the Aleutians and at Nome during the first half of the month and quite low pressure thereafter. At interior stations in the Yukon Basin pressure alternately rose and fell but on the whole low pressure was the rule, there being but three short periods of above normal pressure. Along the coast the fluctuations were generally in close agreement with those of the interior.

The first great depression of the barometer in the Aleutians was felt almost simultaneously over the Canadian northwest and from the Rocky Mountains westward to the coast; in fact pressure began to fall at Prince Rupert on the British Columbia coast 24 hours in advance of its fall at Dutch Harbor. The second great depression of the barometer in the Aleutians beginning on the 17th was not immediately reflected in the Canadian northwest, the interior of Alaska, or the western portion of the United States but pressure continued low along the Alaskan coast and also in the Yukon Basin after the 21st.

THE WEATHER OF THE MONTH.

The weather of the month as conditioned upon the pressure distribution may be briefly summarized as follows: The lows during the first half of the month, as in the month of October, were decidedly lacking in intensity and generally moved eastward along the northern circuit. As a consequence temperature was above the normal in northeastern districts east of the Mississippi. The central portion of the country from the Atlantic to the Pacific was mostly under the influence of high pressure attended by clear radiation weather and little precipitation. In the south the prevalence of northerly winds caused a general lowering of the temperature and there was an excess of precipitation.

After the 15th there was a marked increase in the intensity of the LOWS but not a corresponding increase in the vigor of the HIGHS. There were no cold waves in any part of the country.

The absence of high winds in the Lake region and along the Atlantic coast was a prominent feature of the month, although cyclonic depressions of marked intensity crossed the Lake region on several occasions, as noted in the paragraphs under the caption "LOWS."

HIGHS.

The great majority of the HIGHS, plotted on chart I, apparently had their origin over the Pacific and moved inland as shown. It would seem that practically throughout the month pressure was above the normal off the California coast and considerably below along the Alaskan coast and indeed over interior Alaska during the last half of the month. This pressure distribution resulted in what may be called a "pinching off" from the semipermanent Aleutians LOW of more or less perfectly organized systems of low pressure which moved eastward along the northern circuit. In the rear of each depression thus separated from the principal depression an area of high pressure would pass inland from the Pacific, some of which traversed the continent, while others disappeared over the Plains States and Mississippi Valley. The month affords several examples of the very rapid disappearance of highs over the Plains States entirely at variance with the somewhat prevalent idea that HIGHS are of greater stability than LOWS. HIGHS Nos. VI and VII and VIIA are examples in point. On the 17th a great area of high barometer with central pressure 30.40–30.50 inches occupied the Rocky Mountain region. A cyclonic depression of low barometer level (29.40 inches) was centered over Iowa and practically the whole territory east of the Rocky Mountains was under its direct influence.

Two days later the Rocky Mountain anticyclone had entirely disappeared and the Mississippi Valley cyclone had deepened and the orientation of its longer axis had changed from north-south to east-west. Meanwhile a fresh cyclone had moved inland from the Pacific over central California, the first of the present season to enter the continent below latitude 40° N. At this time, morning 19th, a marked rise in pressure had overspread Alberta. This rise advanced southward and eastward as two distinct waves, the first reached Montana in 24 hours and the West Gulf States 48 hours later; the second wave crested over Saskatchewan on the evening of the 21st with a pressure of 30.90 inches, track No. VII. This anticyclone spread southward, fan-shaped during the 21st–22d attended by northerly winds and light snow on its front; the snowfall overspread Oklahoma, the Texas Panhandle, and the Rocky Mountain region in the west and reached northern Illinois and southern Michigan to the east of the Mississippi. With the advance of this great anticyclone into lower latitudes on the 23d it began to disintegrate and quickly disappeared.

In connection with the disappearance of anticyclone represented by track No. VI, I venture the following forecasting precept: *An anticyclone central over the Rocky Mountains with its longer axis north-south and highest central pressure over Wyoming or Colorado becomes unstable on the approach of a cyclone from the Pacific, provided a second fairly strong cyclone is centered to the eastward over the Mississippi Valley.* The reasoning is as follows. The fact that pressure is highest in the central portion of the HIGH and not in the northern end suggests that the weather map HIGH is, more or less, artificial due to the inherent difficulty in the reduction of plateau pressures to sea level during cold radiation weather, further that the anticyclone's supply of air from higher latitudes is probably shut off and that the withdrawal of air toward the respective cyclone centers must diminish the volume of air within the anticyclone unless fresh air flows in aloft which seems improbable under the pressure distribution as described. As a consequence the anticyclone must quickly disappear.

LOWS.

Sixteen LOWS have been plotted on Chart III, rather evenly divided as to place of origin, or first appearance on the Weather Map, among the following provinces, Alberta, North Pacific, and Middle Rocky Mountains.

LOWS of the last named group of which 4 were observed developed as secondary LOWS over eastern Colorado as the primary LOWS passing eastward over the northern circuit failed to preserve their original intensity and speed of progression. As has been noted previously in this section of the Review the failure of a primary LOW to retain its intensity and speed of movement is almost invariably followed by the development of a secondary depression to the southwest which depression, so far as forecasting for the United States is concerned, becomes the principal one. The origin and development of these secondaries is, at times, obscure and practically impossible of detection 36 hours in advance. Such a secondary is plotted as Low No. I. This disturbance reached its greatest development on the morning of the 3d when it became circular in form with perfect cyclonic wind circulation. It gradually lost intensity thereafter and passed off to sea over the southern New England coast on the morning of the 4th.

Low No. II passed inland from the Pacific as a shallow depression which developed into a trough of LOW pressure over the northern plateau on the morning of the 4th and moved thence northeastward into Canada. Pressure remained low in its rear and a secondary disturbance which has been plotted as IIA was the result.

Low No. III was probably a deep depression whose center was north of the field of observation. It was followed by another still deeper depression No. IV that appeared to lose momentum in Alberta during the afternoon of the 13th although the barometer sank to 29.08 inches. Pressure rose during the next 24 hours and a third deep depression—barometer 28.96 inches off Washington coast—moved inland. It likewise failed to continue its advance to the eastward and pressure rose rapidly along the Pacific coast; the center of the cyclonic activity was therefore displaced to the southward and eastward and a secondary disturbance developed over the Texas Panhandle which by the morning of the 16th appeared over eastern Kansas as a well defined cyclone (see No. VA). For some reason not evident from surface conditions, pressure on the evening of the 18th in the western end of this disturbance remained low and two separate centers, one in the east and one in the west, were in evidence. The western center has been plotted on Chart II as LOW No. VB. The two separate cyclonic centers within one great depression persisted until the evening of the 20th when they apparently united off Cape Cod and passed off to sea on the 21st. Meanwhile Low-track No. VI had advanced from the Pacific to the Canadian Northwest where it disappeared on the evening of the 18th. No. VI was followed by No. VII which moved eastward over the southern circuit disappearing in the East Gulf States on the 21st.

Low No. VIII appears to have been a secondary depression which developed in the rear of No. VII; it was stationary over the southern plateau region from the morning of the 23d until the evening of the 25th when it disappeared owing to rising pressure to the north and west.

Low No. IX moved eastward with its southern margin barely touching the northern border of the weather map.

Lows No. X and XI followed the same course as the above starting the one 24 hours, the other 60 hours later. Both appear to have been merely the southern extension of principal LOWS whose centers were to the northward of the present field of observations.

Low No. XIA was a secondary that developed in the southern end of the trough of No. XI during the 27th. It recurred during the night of the 27th and on the morning of the 28th was central over Illinois as a vigorous cyclone with central pressure of 29.6 inches. It moved northeastward across the Lake region as a storm of high shifting winds, especially over Lake Erie with rain in the southern and snow in the northern portions, and reached the Gulf of St. Lawrence on the morning of the 30th.

Finally LOW No. XII moved eastward from Alberta on the morning of the 30th and disappeared north of Lake Huron on December 3.

The chief characteristics of LOWS during the month may be summarized as follows: Northern LOWS predominated, a large portion of which either moved to the northeast beyond the field of observation or dissipated in the Canadian Northwest. An unusually large number of secondary depressions formed in or east of the Rocky Mountains resulting in abnormally low temperature and much snow in the southern Rocky Mountain and plateau regions, and, finally, in the absence of stormy weather on the Great Lakes until the last days of the month considering the number and intensity of LOWS which traversed that region.

WARNINGS.

Storm warnings were issued for one or more of the Great Lakes on the 3d, 5th, 7th, 8th, 16th, 18th, 24th, 28th and 30th and for the Atlantic coast on the 17th, 18th, 24th, 25th, 28th and 30th.

No cold wave warnings were issued and none were necessary. Frost warnings were issued for some part of the Washington forecast district on the 1st, 2d, 3d, 11th, 12th, 13th, 14th, 18th, 20th, 21st, 24th, 25th, 28th, 29th and 30th.

The forecasting for the Washington district was divided between Forecasters Henry and Frankenfield, each working half of the month.

REPORT OF SPECIAL WANRINGS ISSUED DURING THE MONTH OF NOVEMBER, 1918.

Chicago, Ill., forecast district.—No warnings were issued during the month.—*Chas. L. Mitchell.*

New Orleans, La., district.—No cold wave or storm warnings were needed or issued. Frosts were frequent in the interior sections and reached some portions of the coast a few times during the latter half of the month and freezing weather prevailed during a large part of the last decade in the northern portion of the district. Timely warnings of these conditions were issued except for a frost nearly to the coast in southern Texas on the 28th. In this instance an area of low pressure, which was off the central Gulf coast on the 26th and the morning of the 27th, with attendant rainy weather and moderate temperatures, moved rapidly northward over the west Gulf States and the Mississippi Valley during the 27th–28th, increasing in intensity, and was followed by colder weather in Texas on the 28th, with a temperature of 30° at San Antonio and light frost at Corpus Christi.

Warnings of frost or freezing temperature for portions of the district were issued on the 1st, 8th, 9th, 11th, 12th, 13th, 18th, 19th, 20th, 21st, 22d, 23d, 26th, 28th, and 30th and were completely verified in most instances and partially verified at other times.

Stockmen were warned of the snow and hard freeze in the northwestern portion of the district on the 23d-25th, and at other times were advised when unfavorable conditions were expected.

Fire-weather warnings for the forested areas of Arkansas and Oklahoma were issued on the 4th, for Arkansas on the 15th, and for Oklahoma on the 25th, and were verified.—*R. A. Dyke.*

Denver, Colo., district.—Fine, settled weather was notably absent during November; the longest period not under the influence of low pressure somewhere in the district was from the 8th to the 13th, inclusive, an unusually brief period. November usually marks the beginning of the building-up of high pressure in the Great Basin, a stable condition whose influence frequently extends for weeks at a time throughout the western third of the country. While the centers of low-pressure areas from the northwest and north followed the usual track along the northern circuit extensions southward of several of these depressions resulted in the formation of secondary depressions in central and southern districts which, so far as the West is concerned, became more important storms than those from which they were offshoots. Southwestern LOWS also were an important feature of the pressure distribution in that as soon as their fronts crossed the Continental Divide there was a marked movement southward of high pressure from the region north of Montana, thus prolonging the period of cold and stormy weather. This was notably the case from the 22d practically to the end of the month. The eastward progress of western LOWS being blocked in the middle Rocky Mountain and Plains States, they were apparently forced southeastward toward the Gulf of Mexico. Almost simultaneous with the arrival of the front of the depression on the east side of the Continental Divide there was a rapid movement of high pressure southward on the eastern slope, blocking any further eastward movement of the depression. The high pressure extended to the lower Rio Grande, attended by abnormally cold weather and snow beyond the border of southern New Mexico.

The changes in temperature and weather conditions were for the most part included in the daily forecasts, and for southeastern New Mexico a special forecast was furnished on Sunday, the 24th. Cold-wave warnings were not needed, but frost warnings were issued for south-central Arizona on the 7th, 8th, and 9th and on four dates in the latter half of the month.—*Fredk. H. Brandenburg.*

San Francisco, Cal., district.—The month of November was about evenly divided into alternating fair and stormy weather periods of two to four days' duration. The precipitation was heaviest near the coast and was above normal as far north as Grays Harbor, Wash.; also in southeastern Idaho. Although ample precipitation occurred in practically all interior districts, the amounts were less than normal and considerably so in the Willamette Valley and most of Washington. Temperatures averaged slightly above normal along the southern California coast and about 1° F. above in Oregon, Washington, and western Idaho, while in northern California, Nevada, and southeastern Idaho they averaged about 2° F. below normal. As a whole the month was favorable for agricultural operations and grazing, as well as for the growth of winter vegetation.

Small-craft warnings were issued for the north coast on the 1st, 8th, 13th, 21st, 22d, and 26th, and all were fully justified, though on the 8th the wind velocity attained over western Washington would have justified the issuance of southwest storm warnings for that section.

Storm warnings were sent out for the north coast on the 2d, 9th, 10th, 13th, 14th, 15th, 17th, and 23d, for the northern California coast on the 14th, 15th, 17th, and 23d, and for the southern California coast on the 18th, 23d, and 24th. On the 2d the pressure gradient justified the warnings, but the expected high winds did not occur, due to the apparently large center of depression which was not conducive to rapid surface wind movement; this condition could not be determined from our Chart "A" at the time the warnings were issued. On the 14th the warning was especially timely for northern California, and those of the 23d and 24th for southern California were much appreciated by shipping men, who were enabled to minimize the damaging effects of the ensuing high winds by making such precautionary preparations as were possible. No storm occurred without a warning, and the only damage to shipping reported was the wreck at Point Reyes of the gasoline fishing tug *Nata*, of the Monterey Packing Co., which was driven on the rocks early on the morning of the 18th; the captain and crew of three men escaped.

Frost warnings embracing California, Oregon, and Washington were issued on the 5th, 6th, 7th, and 11th, and for California alone on the 8th, 16th, 20th, and 24th to 30th, inclusive; of these warnings those for the 16th, 20th, and 27th were partly verified, and all the others were verified with the exception of one for southern California on the 26th, which failed because increasing cloudiness set in and prevented the formation of frost. The frosts caused little damage, though those early in the month stopped the growth of cotton in California.

During the last decade in southern California strong winds did a little damage by shaking trees and bruising some of the fruit.—*G. H. Willson.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, NOVEMBER, 1918.

By ALFRED J. HENRY, Meteorologist in Charge.

[Dated: Weather Bureau, Washington, Dec. 20, 1918.]

The floods that were in progress at the end of October in the streams of the Atlantic and East Gulf States had subsided by November 4, except in the lower reaches of a few streams.

A rise to slightly above flood stage occurred in the Santee River at Rimini and Ferguson, S. C., on the 20th to 23d. Also the Saluda River at Chappells, S. C., was slightly above the flood stage from the 29th to 30th.

Heavy local rains north of Wichita, Kans., on the 8th caused a very rapid rise in small creeks and northern Wichita was flooded, making it necessary for some people to vacate their homes. The Arkansas River at Wichita rose only 1.4 feet.

Heavy rains in eastern Oklahoma on the 7th and 8th caused a moderate flood in the Neosho River and a near flood in the Verdigris and in the Arkansas below the mouth of the Neosho.

Moderately heavy rains in Texas from the 8th to 22d caused sharp rises in the rivers. The Trinity River was in flood from above Fort Worth to Liberty, Tex., as shown in Table V. At Dallas the river was 14.3 feet above flood stage.

The Colorado River rose rapidly at Marble Falls and Austin, Tex., reaching 2.4 feet above flood stage at the latter place on the 9th. A second rise to slightly above flood stage occurred at Austin on the 11th and 12th. By the morning of the 15th the stream was below flood stage.

Heavy rains on the 7th and 8th caused the Brazos River to rise very rapidly. At Kopperl it rose 14 feet in 2 hours on the 8th. The crest was at 36.5 feet, which is the highest stage of record at that place. "The flood appeared like a huge wave, disappearing as suddenly as it came and flattening out as it rushed along. A crevasse 100 feet wide was made in the levee below Waco and the business streets were flooded to a depth of 2 feet. Had the levee broken above town, a very serious loss would have resulted."

Estimated losses, November, 1918, due to floods.

Districts.	Bridges, highways, etc.	Crops.		Farm property, live stock, etc.	Suspension of business.	Estimated value of warnings.
		Not yet housed.	Prospective.			
Montgomery, Ala.	$4,000	$166,350	....	$2,000	$500	$7,500
Fort Smith, Ark.	....	10,000	$15,000	....	500	2,500
Dallas, Tex.	25,000	15,000	....	7,000	12,000	(?)
Houston, Tex.	41,750	....	....	....	....	(?)
Total	70,750	222,850	15,000	9,000	13,000	....

TABLE I.—*Flood stages in the North and South Atlantic drainage during November, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
	Feet.			*Feet.*	
White River Junction, Vt.	13	(1)	3	14.7	1
Santee:					
Rimini, S. C.	12	(1)	10	19.0	4
Do.	....	20	22	12.5	21
Ferguson, S. C.	12	(1)	12	14.9	5
Do.	....	23	23	12.0	23
Catawba:					
Catawba, S. C.	11	(1)	1	14.2	[2] 31
Wateree:					
Camden, S. C.	24	(1)	2	30.5	[2] 28
Congaree:					
Columbia, S. C.	15	....	....	13.1	1
Broad:					
Blairs, S. C.	15	(1)	1	16.7	[2] 31
Saluda:					
Pelzer, S. C.	7	(1)	1	8.8	[2] 31
Chappells, S. C.	14	1	2	15.1	2
Do.	....	29	(3)	15.4	30

[1] Continued from October. [2] October. [3] Continued into December.

TABLE II.—*Flood stages in the East Gulf drainage during November, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Alabama:	*Feet.*			*Feet.*	
Montgomery, Ala.	35	....	....	34.8	1
Selma, Ala.	35	2	4	38.0	3
Coosa:					
Gadsden, Ala.	22	....	....	21.5	1
Cahaba:					
Centerville, Ala.	25	(1)	1	32.7	[2] 30
Do.				23.9	28
Tombigbee:					
Demopolis, Ala.	39	(1)	7	47.3	4
Black Warrior:					
Tuscaloosa, Ala.	46	(1)	2	51.3	[2] 31
West Pearl:					
Pearl River, La.	13	6	10	13.7	8-9

[1] Continued from October. [2] October.

TABLE III.—*Flood stages in the Mississippi drainage (Ohio basin) during November, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Tennessee:	*Feet.*			*Feet.*	
Knoxville, Tenn.	12	(1)	1	18.7	[2] 31
Riverton, Ala.	32	....	....	30.0	5
French Broad:					
Penrose, N. C.	13	(1)	1	19.5	[2] 30
Asheville, N. C.	4	(1)	2	8.0	[2] 30
Big Pigeon:					
Newport, Tenn.	6	(1)	1	8.3	[2] 30
Clinch:					
Clinton, Tenn.	25	....	....	24.0	1

[1] Continued from October. [2] October.

TABLE IV.—*Floods in the Mississippi River drainage during November, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Arkansas River:	*Feet.*			*Feet.*	
Fort Smith, Ark	22	....	....	20.7	10
Verdigris:					
North Muskogee, Okla	21	....	....	17.1	9
Neosho:					
Wyandotte, Okla	23	....	....	20.0	8
Fort Gibson, Okla	22	9	10	26.0	10

TABLE V.—*Floods in the rivers of Texas during November, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Trinity:	*Feet.*			*Feet.*	
Fort Worth, Tex	20	8	9	28.0	8
Dallas, Tex	25	8	14	39.2	9
Trinidad, Tex	28	11	23	37.6	17
Long Lake, Tex	40	20	24	42.3	22
Riverside, Tex	40	....	....	28.1	28-29
Liberty, Tex	25	29	(1)	25.4	30
Colorado:					
Austin, Tex	18	9	9	20.4	9
Do	....	12	12	18.4	12
Columbus, Tex	28	11	15	33.9	14
Brazos:					
Kopperl, Tex	21	8	8	36.5	8
Waco, Tex	27	8	9	37.1	9
Valley Junction, Tex	44	....	....	34.8	9
Washington, Tex	45	....	....	41.9	11

[1] Continued into December.

SNOWFALL IN MOUNTAINS, NOVEMBER, 1918.

There was considerable snow in the Sierra Nevada of California above the 5,000-foot level, but on account of much sunshine and the prevalence of desiccating winds, much of the snow on these mountains disappeared by the end of the month.

On the high mountains of Colorado, on both sides of the Continental Divide, there was a rather large amount of snow for November. The snow was especially heavy in southern counties in the watershed of the Rio Grande, and also in the central region upon the headwaters of the Arkansas. It was also heavy in western counties on the headwaters of the southern tributaries of the Grand River and the upper tributaries of the San Juan River. By the close of the month there was considerable snow cover, 10 inches or more, on the higher levels of the above-named districts. As a general rule heavy snow this early in the season is of small importance so far as available water at the end of the snow season is concerned.

MEAN LAKE LEVELS DURING NOVEMBER, 1918.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Dec. 4, 1918.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during November, 1918:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.54	581.14	572.24	246.00
Above or below—				
Mean stage of October, 1918	+0.05	−0.04	−0.05	0.00
Mean stage of November, 1917	+0.10	−0.04	−0.74	−0.69
Average stage for November, last 10 years	+0.07	−0.04	+0.47	+0.44
Highest recorded November stage	−0.97	−1.78	−1.43	−1.82
Lowest recorded November stage	+1.04	+1.96	+1.54	+2.59
Average relation of the November level to—				
October level	−0.2	−0.2	−0.3	−0.3
December level	+0.2	+0.2	+0.2	+0.2

*Lake St. Clair's level: In November, 575.33 feet.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR NOVEMBER, 1918.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Dec. 3, 1918.]

TABLE 1.—*Noninstrumental earthquake reports, November, 1918.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1918.	*H. m.*		° ′	° ′			*M. s.*			
Nov. 8	18 24	Calexico	32 41	115 30	4	1	20	None	Trembling, jarring	H. M. Rouse.
15	7 47	Lone Pine	36 37	118 02	4	3	Few	None	Abrupt bumping	A. F. Marsh.
19	20 15?	Port Los Angeles	34 02	118 30	5	1	4	None	Bumping from west to east	A. P. Deraga.
	20 19?	Santa Monica	34 02	118 30	5	1	3	Faint	Abrupt bump	Nelle Barker-Bates.
	20 18?	Venice	33 58	118 28	7	2	30	Yes	Like an explosion, a sudden dropping sensation. Plaster and dishes thrown to the floor.	Dr. Jas. T. Brown.
20	22 41	Mount Wilson	34 13	118 04	2	1	10		Gradual rocking in all directions.	Wendell P. Hoge.
29	23 24	Eureka	40 48	124 11						James Jones.
		Table Bluff	40 41	124 10	5	1	2	Loud	Abrupt bumping and jarring, east to west.	A. F. Peters.
		PORTO RICO.								
10	20 17	San Juan	18 29	66 07	3	1	6	None	Abrupt trembling	F. E. Hartwell.
12	12 01	San Juan	18 29	66 07	4	1	8	None	Gradual rocking	F. E. Hartwell.
	21 43	San Juan	18 29	66 07	6	1	15	None	Gradual bumping and trembling.	F. E. Hartwell.
		UTAH.								
16	12 45?	Clarkston	41 55	112 03	5	1	1 00	Yes	Gradual rocking E–W	W. J. Griffiths.
17	12 43?	Tremonton	41 42	112 10		2	3	Yes	Gradual trembling S–N	A. J. Rosa.

TABLE 2.—*Instrumental seismological reports, November, 1918.*

(Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.)

[For significance of symbols see REVIEW for January, 1918, p. 34.]

Alabama. *Mobile. Spring Hill College.* Earthquake Station. Cyril Ruhlmann, S. J.

Lat., 30° 41′ 44″ N.; long., 88° 08′ 46″ W. Elevation, 60 meters.

Instrument: Wiechert 80 kg.; astatic, horizontal pendulum.

(Report for November, 1918, not received.)

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 18 \\ N & 10 & 17 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*km.*	
Nov. 8	....	P	4 46 22	3				N not in good adjustment.
		eL_N	5 00 30	20				
		eL_E	5 00 33	26				
		M_N	5 05 25	20		260		
		M_E	5 05 49	18	30			
		C_N	5 17 ..	17				
		F_E	5 38 ..	15				
		F_N	6 38 ..	10				
18	....	eP_N	18 59 05					Phases not well defined.
		eP_E	18 59 18	4				
		S?	19 05 22					
		M_E	19 08 49		40			
		eL?	19 13 25					
		M_N	19 13 40			50		
		F_E	19 43 ..	8				
		F_N	19 46 ..	14				

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. William H. Cullum.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 14 \\ N & 10 & 18 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*km.*	
Nov. 8	....	P	4 49 34	4				Instrument not in good adjustment during November; does not show smooth regular waves.
		S	4 59 10					
		eL_N	5 13 25					
		M_N	5 14 07			80		
		eL_E	5 15 00					
		M_E	5 22 10	18	150			
		C	5 27 ..					
		F_N	6 26 ..					
		F_E	7 23 ..					
12	....	eP_E	21 54 20	5				Nothing visible on N.
		eL_E	22 12 40					
		M_E	22 15 10	15	10			
		F_E	22 52 ..					
16	....	eP_E	6 06 09	5				
		S_N	6 09 10					
		S_E	6 09 12					
		eL_E	6 11 20					
		M	6 12 ..	10	10	10		
		F	6 13 ..					
18	....	eP_E	19 01 51					Phases doubtful; nothing definite on N.
		eP_N	19 02 20					
		eL_E	19 36 ..					
		F_N	19 42 ..					
		M_E	19 51 ..		30			
		F_E	21 12 ..					

TABLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Nov. 9					100	200		Tremors during 24 hours preceding 16h 00m on dates given.
10					100	150		
17					50	100		
20					300	300		

California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 63″ W. Elevation, 27.43 meters.

(See record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat. 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Oct. 4		L_N	20 28 ..					
		F_N	20 36 ..					
4		L_N	21 50 ..					
		F_N	22 02 00					
4		L_N	22 35 ..					
		F_N	22 41 ..					
8		P	4 59 ..					Time of first preliminary somewhat doubtful. Second preliminary not discernible.
		S	5			*250		
		L	5 15 ..	20-30	*250			
		M	5 19 ..	20	*2,250	*2,000		
		C	5 25 ..					
		F	5 39 ..					
23		L_N	21 06 ..					
		F_N	21 27 ..					

* Trace amplitude.

District of Columbia. *Washington, U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. $\begin{cases} V & T_0 \\ 110 & 6.4 \end{cases}$

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918			*H. m. s.*	*Sec.*	*μ*	*μ*	*km*	
Nov. 2		e_N	10 33 12					
		L	10 34 10	12				
		F	11 00 ..					
3		e_N	11 36 00					Small amplitudes soon lost in microseisms.
		F	? ? ?					
5		P_N	22 45 48					
		S_N	22 50 58					
		L_N	22 56 15	20				
		F	23 15 ..					
8		P	4 50 40					
		S	5 01 12					
		L	5 17 30	22				
		L	5 20 00	30				
		L	5 25 00	20				
		L	5 35 00	16				
		F	8 15 ..					
9		e	0 15 30					Small amplitudes. Confused with microseisms.
		F	0 25 ..					
12		P	21 49 43					F lost in microseisms.
		S	21 53 48					
		L	21 55 40	20				
		L	22 00 00	16				
		F	22 45 ..					
18		P	19 01 00					Difficult to read; distant quake.
		$P_{rep 1}$	19 04 05					
		L	19 44 00	35				
		L	19 56 00	20				
		F	21 10 ..					
23		e	23 17 13					
		S?	23 20 10					
		L	23 39 00	24				
24		L	0 12 00	20				
		F	0 30 ..					
30		e	7 28 00					
		L	7 32 00	18				
		F	7 45 ..					

TBBLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

District of Columbia. *Washington. Georgetown University.*

F. A. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants	*V*	T_0	ε
E	165	5.4	0
N	143	5.2	0
Z	*80*	*5.0*	*0*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918			*H. m. s.*	*Sec.*	μ	μ	*km*	
Nov. 2	....	L_N....	10 34 ..	10	......	......	......	Microseisms.
		L_E....	10 38 ..	10	......	......	......	
		F.....	11	....	......	......	......	
3	....	L_E....	12 28 ..	....	......	......	......	Do.
		F.....	13 (ca)	....	......	......	......	
8	....	P.....	4 50 47	....	......	......	......	Do.
		S_N....	5 01 25	....	......	......	......	
		S_E....	5 01 34	....	......	......	......	
		eL_E...	5 17 00	24	......	......	......	
		eL_N...	5 17 18	27	......	......	......	
		M_N....	5 29 12	11	......	*1,700	......	
		M_E....	5 29 32	22	*1,500	......	......	
		F.....	8	....	......	......	......	
			VERTICAL.			*Az*		
8	....	*P*.....	*4 50 41*	....	......	......	......	*S doubtful. No distinct main.*
		i......	*4 51 08*	....	......	......	......	
		eL.....	*5 17 24*	*19*	......	......	......	
		F.....	*7 54 ..*	....	......	......	......	
12	....	iP....	21 49 47	....	......	......	......	Heavy microseisms. No distinct main. F surely after 23 hours.
		iS_N....	21 53 52	....	......	......	......	
		iS_E....	21 54 00	....	......	......	......	
		eL....	21 55 48	....	......	......	......	
		F.....	.. .. ..	....	......	......	......	
18	....	P.....	19 01 08	....	......	......	......	Possibly overlapping quakes. F difficult because of microseisms. No distinct main.
		i_N.....	19 04 44	....	......	......	......	
		i_E.....	19 04 48	....	......	......	......	
		S_E.....	19 13 55	....	......	......	......	
		S_N?...	19 14 10	....	......	......	......	
		i_E.....	19 22 28	....	......	......	......	
		L_E....	19 42 40	21	......	......	......	
		L_N....	19 44 ..	26	......	......	......	
		F.....	21	....	......	......	......	
22	....	e......	16 30 ..	....	......	......	......	
		eL_E...	16 38 ..	9	......	......	......	
		eL_N...	16 38 24	7	......	......	......	
		F.....	16 53 ..	....	......	......	......	
30	....	L_E....	7 26 ..	22	......	......	......	Heavy microseisms.
		L_N....	7 31 ..	16	......	......	......	
		F.....	7 50 ..	....	......	......	......	

*Trace amplitudes.

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Frank Neumann.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant..T_0 18. Sensitiveness 0″.40

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*km.*	
Nov. 2	....	L.....	10 02 00	....	......	......	......	Sharp earthquake reported from the island of Hawaii, with renewed activity of Kilauea.
		M.....	10 03 54	....	9.4	......	......	
		C.....	10 11 ..	....	......	......	......	
		F.....	10 48 ..	....	......	......	......	
3	....	e......	11 53 54	....	......	......	......	P was probably obscured by the irregular motion of the paper.
		L.....	11 56 06	....	......	......	......	
		M.....	12 00 30	....	0.5	......	......	
		C.....	12 06 ..	....	......	......	......	
		F.....	12 55 ..	....	......	......	......	
8	....	P.....	4 45 36	17	......	......	......	Pen beyond limits of paper for two minutes at time of maximum. Paper not moving at a uniform rate.
		S.....	4 53 00	18	......	......	......	
		eL....	5 02 48	....	......	......	......	
		M.....	5 05 ..	....	17+	......	......	
		C.....	6 22 ..	18	......	......	......	
		F.....	8 35 ..	17	......	......	......	
12	....	eP....	21 58 30	....	......	......	......	
		L.....	22 25 48	....	......	......	......	
		M.....	22 36 18	18	0.1	......	......	
		C.....	22 42 ..	18	......	......	......	
		F.....	25 27 ..	19	......	......	......	
14	....	eP....	16 22 06	....	......	......	......	
		L.....	16 33 18	....	......	......	......	
		M.....	16 37 00	....	0.1	......	......	
		C.....	16 40 ..	....	......	......	......	
		F.....	17 10 ..	....	......	......	......	
18	....	P.....	18 53 48	....	......	......	......	Paper not moving at a uniform rate.
		S.....	19 02 48	....	......	......	......	
		L.....	19 17 00	....	......	......	......	
		M.....	19 28 06	....	15.0	......	......	
		C.....	19 55 ..	18	......	......	......	
		F.....	21 48 ..	19	......	......	......	
22	....	P.....	16 03 24	17	......	......	......	Preceded and followed by air tremors.
		L.....	16 15 00	....	......	......	......	
		M.....	16 19 12	18	0.5	......	......	
		C.....	16 22 ..	17	......	......	......	
		F.....	? ? ?	....	......	......	......	
23	....	eP....	23 10 24	18	......	......	......	
		S.....	23 19 18	18	......	......	......	
		L.....	23 33 42	....	......	......	......	
		M.....	23 46 06	18	1.0	......	......	
		C.....	24 01 ..	18	......	......	......	
		F.....	25 47 ..	....	......	......	......	
30	....	e......	7 15 ..	....	......	......	......	
		M.....	7 20 ..	....	0.1	......	......	
		F.....	7 39 ..	....	......	......	......	

TABLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.
Instrument: Wiechert.

Instrumental constants	V	T_0	ϵ
E	177	3.4	4:1
N	205	3.4	4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 8		iP_E	4 49 56					
		iP_N	4 49 57					
		S_E	4 59 49					
		S_N?	5 00 06					
		L_E?	5 09 07					
		L_N?	5 09 15					
		M_E	5 22 40		8.6			
		M_N	5 27 44			6.8		
		F	7 00 ..					
12		P_N	21 51 09					Primary confused by clock signals. S not discernible.
		P_E	21 51 12					
		L_N?	22 00 33					
		L_E?	22 02 56					
		M_E	22 06 43		3.4			
		M_N						Lost.
		F	22 23 ..					
18		eP_E	19 00 47					
		eP_N	19 00 49?					
		S	19 02 54					
		L	19 04 05					
		M	19 04 13		8.8	5.6		
		F_E	20 59 ..					

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N; long., 76° 50′ 30″ W. Elevation, 71.6 meters.
Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants	V	T_0
E	10	15
N	10	15

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 2		eL_N	10 38 30					
		M_N	10 40 30	11		10		
		F_N	10 43 ..	10				
8		P	4 51 00	3				
		S_N	5 01 37	4				
		eL_N	5 19 10					
		eL_E	5 23 40					
		M_E	5 32 35	18	40			
		C_E	5 38 ..	15				
		M_N	5 40 48	14		210		
		C_N	5 49 ..	15				
		F_E	5 52 ..					
		F_N	6 57 ..	15				
12		P	21 49 37	3				No long waves on E.
		S_N	21 53 42					
		L_N	21 55 46	23				
		M_N	21 59 52			60		
		C_N	22 04 ..	18				
		F_E	22 17 ..					
		F_N	22 36 ..					
18		e_N	19 01 07					Phases doubtful.
		e_E	19 01 10					
		S?	19 04 52					
		eL_N	19 15 ..					
		M_N	19 45 18			40		
		F_E	20 06 ..					
		F_N	20 55 ..					
23		e_N	23 20 ..					
		e_E	23 20 50					
		F_E	23 29 ..					
24		eL_N	0 12 30					
		M_N	0 17 ..	20		10		
		F_N	0 27 ..					

Massachusetts. *Cambridge. Harvard University Seismographic Station,* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants	V	T_0	ϵ
E	80	23	0
N	50	25	4:1

(Report for November, 1918, not received.)

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ϵ 5:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 8		P_N	4 50 12				8,700	
		S_N	5 00 18					
		L_N	5 15 12					
		L_E	5 16 09					
		M_N	5 21 12	24		*30,000		
			5 25 06	21		*36,000		
		M_E	5 21 12	24	*24,000			
		F	6 34 ..					
12		eP?	21 50 42				3,300?	P difficult to determine on account of microseisms.
		S	21 55 48					
		L	21 58 18					
		L	22 03 24	18		*12,000		
		L	22 04 24	12		9,000		EW not working satisfactorily.
		F	23 00 00					
17		eL	22 59 09					17th and 18th impossible to decipher on account of high wind influence.
		F	23 25 00					
18		iS?	19 04 21					Nov. 19-20; 25-26; and 26-27, record full of micorseisms.

*Trace amplitude.

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V 80, T_0 7, ϵ 5:1

(Report for November, 1918, not received.)

New York. *Fordham. Fordham University.* Daniel H. Sullivan, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert, 80 kg.

Instrumental constants	V	T_0	ϵ
E	72	5.0	0
N	72	5.0	0

(Report for November, 1918, not received.)

TABLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long. 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

Instrumental constants	V	T_0	ϵ
E	13	22	4:1
N	14	25	4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 3		eL_E	12 27 ..	20				
		F_E	12 58 ..					
8		P_E	4 50 45	3				
		P_N	4 50 46	3				
		$P_{rep\,1}$	4 54 08	5				
		S_N	5 01 06	7				
		S_E	5 01 14	9				
		L_E	5 16 05	30				
		L_N	5 16 35	30				
		M_E	5 28 11	18	*1,900			
		F_E	8 26 ..					
12		eP_N	21 50 13	3				Microseisms.
		eP_E	21 50 15	3				
		S_E	21 54 39	7				
		S_N	21 54 41	5				
		L_E	21 56 26	25				
		L_N	21 56 44	20				
		F_E	22 45 ..					
18		eP_N	19 02 07	7				
		eP_E	19 02 09	6				
		i_N	19 05 52	8		*500		
		i_E	19 05 53	7				
		eS_E	19 14 07	8				
		eS_N	19 14 44	10				
		eL_E	19 38 40	32				
		F_E	21 37 ..					

* Trace amplitude.

Panama Canal. *Balboa Heights.* Governor, Panama Canal.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants	V	T_0
	35	20

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 5		P_E	22 42 16				910	
		P_N	22 42 18					
		L_E	22 44 16	20				
		L_N	22 44 18	20				
		M_E	22 44 52		*500			
		M_N	22 44 54			*700		
		F_E	22 49 ..					
		F_N	22 51 ..					
8		P	4 57 00	20	*300	*200		
		F	6 34 ..					
12		P_E	21 48 02				990	
		P_N	21 48 06					
		L_E	21 51 00	20				
		M_N	21 51 14			*1,700		
		L_N	21 51 18	20				
		M_E	21 51 34		*500			
		F	22 12 ..					
18		P_E	19 01 28					
		P_N	19 01 36					
		L_E	19 24 18?	20				
		L_N	19 24 42?	20				
		M_E	19 ? ?		*700			
		M_N	19 24 48			*1,000		
		F	20 33 ..					
23		P	23 18 00	20				Faint tremors.
		F	23 26 ..					
29		P_E	4 23 02				330	
		P_N	4 23 04					
		L_E	4 23 44	20				
		L_N	4 23 52	20				
		M_E	4 24 26		*500			
		M_N	4 24 28			*400		
		F_N	4 29 ..					
		F_E	4 30 ..					
29		P_E	18 11 12				90	Direction probably southerly.
		P_N	18 11 13					
		L_E	18 11 19	20				
		L_N	18 11 20	20				
		M_N	18 11 21			*1,300		
		M_E	18 11 23		*1,400			
		F_N	18 13 11					
		F_E	18 14 00					

* Trace amplitude.

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wallace M. Hill.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants	V	T_0
E	10	17
N	10	20

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 7		P_N	9 33 56	1				Not far distant.
		P_E	9 33 59	1				
		M_N	9 34 14			10		
		M_E	9 34 23		20			
		F	9 38 ..					
8		eP	4 56 59	5				This may be $P_{rep\,1}$.
		eS	5 12 36					This may be $S_{rep\,1}$.
		eL	5 35 28					On E there are two regular waves, period 28 sec., beginning at 5h. 22m. 10s., and four waves, period about 40 sec., beginning at 5h. 26m. 30s.
		M_E	5 36 08	22	40			
		M_N	5 46 48	20		70		
		C	5 53 ..	17				
		F_N	6 01 ..	17				
		F_E	6 15 ..	17				
12		iP	12 02 26	1				Not far distant.
		L	12 02 50					
		M	12 03 05	6	80	200		
		F	12 12 ..	4				
12		iP	21 45 14	3				Not far distant. Felt at Vieques.
		eL	21 45 34					
		M	21 46 02	16	6,380	3,340		
		C	21 49 ..	12				
		F	22 19 ..	10				
18		iP_N	19 01 50	6				
		eP_E	19 02 25	6				This may be P_{rep1}
		eL_E	19 47 10					
		eL_N	19 58 00					
		M_E	20 03 08	30	30			
		M_N	20 05 12	30		10		
		C	20 08 ..	28				
		F_N	20 34 ..	20				
		F_E	20 42 ..	22				
[illegible]		P_N	7 21 44	2				Not far distant.
		eP_E	7 21 57					
		M_E	7 22 15		30			
		M_N	7 22 20			20		
		F_E	7 24 ..	3				
		F_N	7 28 ..	3				

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants	V	T_0
E	10	15
N	10	16

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 8		P	4 50 32					
		S	5 00 57					
		L	5 16 00	20				
		L	5 20 30	24				
		L	5 25 30	20				
		L	5 34 30	16				
		F	7 00 ..					
12		P	21 50 38					
		S?	21 54 42					
		L	21 58 00	16				
		F	22 30 ..					
18		P	19 00 59					Distant quake. Record apparently confused.
		S	19 04 38					
		eL?	19 26 00					
		L	19 37 00	60				
		F	20 45 ..					
23		e?	23 16 10					
		F	23 16 40					

TABLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants.. V 120 T_0 26

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 2		e_N?	10 28 24					
		e_N	10 33 30	10				
		e	10 35 00	10				
		L	10 38 ..	8				
		L	10 40 ..	7				
		L	10 44 ..	6				
		F	11					
3		e	11 36 30	7				Early phases on NS confused in heavy micros. Beautiful sinusoidal L waves.
		e?	11 55 ..	12				
		e_N	12 15 ..	40?				
		eL_E	12 21 ..	30				
		L	12 29 to	18	to			
			12 38 ..	15				
		L	12 42 ..	15				
		L_E	13 00 ..	14				
		F	13 15 ..					
5		i	22 48 29	3				
		eL	22 59 ..	20				
		F	23 15 ..					
8		*O*	*4 38 50*				8,180	Very long period of the S_{repl} waves. First read as L, which they closely resemble.
		iP	4 50 20					
		eP_{repl}	4 53 25					
		eS	4 59 49					
		eS_{repl}	5 05 54	36				
		eL	5 14 30	32				
		L	5 25 ..	18				
		L	5 45 ..	17				
		L	6 00 ..	12				
		L	6 25 ..	12				
		L	6 40 ..	12				
		L	6 50 ..	10				
		L	6 55 ..	10				
		L	7 06 ..	10				
		F	8 00 ..					
		HALIFAX RECORD.						
8		*O*	*4 38 36*				9,380	Halifax record furnished by Ottawa.
		P	4 51 08					
		S	5 01 37					
		L?	5 14 30	45				L waves arrive too soon by about 7 minutes, appearing at the time SR should appear, but with a period of 45s.
		SASKATOON RECORD						
8		*O*	*4 38 49*				7,100	Saskatoon record furnished by Ottawa.
		P	4 49 22					
		S	4 57 56					
		L?	5 06 ..					L waves arrive 4 minutes too soon. They may be S_{repl}, but there is no break between them and the true L.
9		e	0 17 to					
		F	0 30 ..	8				May not be seismic.

Canada. *Ottawa. Dominion Astronomical Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
		SASKATOON RECORD—Con.						
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 10		e	13 00 to					
		F	13 05 ..	6				May not be seismic.
10		e	15 47 to	22				Very small amplitude. NS is confused with wind and micros.
		F	15 50 ..					
11		eL	8 04 to					
			8 10 ..	15				
12		*O*	*21 45 00*				2,880	
		eP	21 50 45					
		eS	21 55 19					
		eL	21 58 ..	24				
		L	22 05 ..	14				
		L	22 22 ..	14				
		F	22 45 ..					
16		eL_E	6 15 to					Very slight indication. NS record is lost in microseisms.
		F	6 25 ..					
18		i	19 01 01					Phases confused. No readings obtained. Halifax and Sasketoon records equally unreadable. The records indicate that the disturbance came from the east. Tidal wave at Newfoundland on same date and was probably connected with this earthquake, according to reports received from Halifax.
		i	19 03 40					
		i	19 04 32					
		$e?_E$	19 23 18	25				
		eL	19 39 ..	60				
		L	19 50 ..	30				
		L	20 00 ..	20				
		L	20 20 ..	18				
		L	20 35 ..	18				
		L	21 01 ..	16				
		F	21 30 ..					
22		e	16 31 ..					Heavy micros.
		eL	16 38 ..	17				
		L	16 44 ..	17				
		F	17 10 ..					
23		i	23 20 20					
		i	23 20 35	4				
		i	23 21 14	7				
		e_N	23 31 30	10				
24		L?	0 05 ..	28				
		L	0 20 ..	16				
		F	0 50 ..					
25		e_N	2 27 18	6				Very small amplitude. Record barely discernible.
		eL_E	2 30 30					
		L_E	2 33 ..	18				
		L_N	2 35 ..	13				
		F	2 40 ..					Seismograph out of commission from 14h. 30m. Nov. 25 to 18h. 00m. Nov. 28.
30		eL	7 17 18					
		L_E	7 22 ..	19				
		L	7 25 ..	17				
		L	7 30 ..	14				
		L	7 34 ..	9				
		F	7 55 ..					

TABLE 2.—*Instrumental seismological reports, November, 1918*—Continued.

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North; in the meridian.

Instrumental constant..18 T_0. Pillar deviation, 1 mm. swing of boom=0.45″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 2		L	10 45 24					
		L	10 54 24		*50			
3		L	12 25 12					Time doubtful.
		L	12 28 36					
		M	12 30 48		*700			
		F	13 44 12					
5		L	22 58 30					
		iL	23 00 48					
		M	23 02 30		*200			
		F	23 23 06					
8		eP	4 50 48				8,560	Clear record. Epicenter, lat. 51° 26′ N, long. 145° East.
		iP	4 54 00					
		eS	5 00 36					
		iS	5 05 54					
		iL	5 11 00					
		iL	5 14 24					
		iL	5 24 36					
		M	5 29 00		*14,000			
		iL	5 33 42					
		iL	5 37 24					
		iL	5 46 54					
		L	6 14 00					
		F	9 18 42					
11		L	7 57 24					
		L	8 02 48		*100			
		F	8 17 36					
12		P	21 50 54				2,990	
		S	21 55 36					
		L	21 57 48					
		L	22 00 00					
		eL	22 01 06					
		M	22 05 12					
		F	23 17 30		*3,300			
16		L	6 14 48					Small micros.
18		P	19 00 00?				3,070?	May be a dual 'quake. S waves large.
		iS	19 04 48					
		eL	19 15 06					
		M_1	19 24 18		*2,000			
		iL	19 47 36					
		eL	20 02 42					
		M_2	20 06 48		*3,000			
		eL	20 45 54					
		F	Micros.					
22		L?	16 33 30					
		L	16 37 36					
		M	16 43 30		*300			
		F	16 56 36					
23		P?	23 25 42					
		S?	23 36 18					
		L	23 46 36					
24		eL	0 17 54					
		M	0 22 30		*300			
		eL,repl	1 04 30					
		eL	1 08 54					
		F	1 38 42					
25		L	2 27 18					
		eL	2 35 18					
		M	2 36 18		*300			
		F	3 12 12					
26								Heavy micros. began after 22 hours, continuing to 15 hours of the 27th.
30		eL	7 23 48					Disturbance abruptly became smaller at 7h 31m 24s.
		M	7 28 24					
		L	8 16 24		*400			
		F	8 18 24					

*Trace amplitudes.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instruments: Wiechert, vertical. Milne horizontal pendulum, North; in the meridian.

Instrumental constant..18T_0. Pillar deviation: 1mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E.	Amplitude. A_N.	Distance.	Remarks.
Nov. 3		P	11 43 34				9,310	
		S	11 54 00					
		L	12 06 31					
		eL	12 19 02					
		M	12 24 03		*500			
		F	12 32 04					
8		P	4 47 25				4,180	Kamchatka.
		S	4 53 22					
		L	5 03 47					
		M	5 20 29		*6,000			
		F	8 48 01					
			VERTICAL.			*Az.*		
		P	*4 47 00*	*2–3*			*5,050*	*Kamchatka.*
		S	*5 53 45*	*8*				
		L	*5 04 40*	*24*				
		M	*5 22 08*	*24*		*14*		
12		P	21 54 14				6,330	May be West Indies.
		S	22 02 08					
		L	22 12 52					
		M	22 20 28		*1,000			
		eL	22 27 20					
		F	23 05 06					
16		P	6 14 04?					
		L	6 18 59					
		M	6 20 27		*200			
		F	6 27 50					
18		P	18 55 14				2,770	S waves well defined.
		S	18 59 40					
		L	19 08 02					
		M	19 44 25		*9,000			
		eL	20 57 33					
		eL	21 01 09					
		M,repl	21 05 09		*1,000			
		eL	21 13 45					
		F	22 01 09					
			VERTICAL.			*Az.*		
		S	*19 00 18*	*3–4*				
		L	*19 07 38*	*14*				
		M	*19 44 34*	*36*		*4*		
		F	*? ? ?*					
20		M	6 57 19		*100			
22		P	16 05 00?					
		M	16 29 30		*200			
		F	17 01 30					
23		P	23 21 36				7,400?	
		e	23 28 14					
		S	23 30 27					
		L	23 41 45?					
		L	23 46 11?					
24		M	0 06 51		*500			
		F	1 33 24					
30		S	7 09 03					Disturbance abruptly became less at 7h 24m 04s.
		L	7 16 44					
		M	7 22 07		*400			
		F	7 41 02					

*Trace amplitudes.

SEISMOLOGICAL DISPATCHES.[1]

San Juan, P. R., October 25, 1918.

Another heavy earthquake shock was felt at 11.15 o'clock last night. The disturbance is reported to have caused further property loss at Mayaguez and Ponce, and small loss of life and property at Aguadilla. (Assoc. Press.)

Honolulu, Hawaii, November 4, 1918.

Spouting lava a hundred feet from new cracks in the old floor Saturday morning, the crater Kilauea entirely buried the old resthouse. The eruption followed severe earthquakes throughout the island of Hawaii Friday night at 11.33 o'clock. The Kilauea fire pit has been rising for three days, and lava is flowing continuously in several directions. (Assoc. Press.)

Rome, Italy, November 11, 1918.

Heavy earth shocks, accompanied by property damage and loss of life occurred Sunday in the provinces of Florence and Forli.

The villages of Santa Sofia, Bagnodiromaga and Mordane particularly suffered. At Santa Sofia a church collapsed, eight persons being killed and several injured. (Assoc. Press.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

San Juan, P. R., November 14, 1918.

Two earthquakes occurred in Porto Rico yesterday, the first at 8 o'clock in the morning, and the second at 6 o'clock in the evening. Both shocks caused some damage in cities reporting losses in the earthquake of last October, but there was no additional loss of life. (Assoc. Press.)

Guatemala, November 16, 1918.

Four earthquake shocks were felt at this place between the hours of 8 and 10 o'clock a. m., local time. (Special observer.)

Guatemala, November 18, 1918.

A shock was felt at 10 o'clock a. m. (Special observer.)

Los Angeles, Cal., November 19, 1918.

An earthquake, sharp enough to rattle windows and jar dishes from shelves, was felt to-day in the southwestern part of Los Angeles and along the ocean as far as Santa Monica. The tremor, which lasted more than half a minute, seemed to be most pronounced at Santa Monica. (Assoc. Press.)

SECTION IV.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Albano, Ildefonso.
O secular problema do nordeste; 2a edição. Discurso pronunciado na Camara dos deputados em 15 de outubro de 1917 . . . Rio de Janeiro. 1918. 3 p. l., [5]-163 p. illus. plates. tables. 24 cm. [Discusses droughts in northeast Brazil.]

Chapman, Frank M[ichler].
The distribution of bird-life in Colombia; a contribution to a biological survey of South America. New York. 1917. x, 729 p. front. (fold. map.) plates. (part. col.) maps (part. fold.) 24½ cm. At head of title: Bulletin of the American museum of natural history. vol. 36, 1917 . . . Bibliography, p. 657-659. [Climatology, p. 79-83.]

Collenette, A.
The rainfall and sunshine of Guernsey for the year 1915. cover-title, 7 p. incl. tables. 22½ cm. (Reprinted from the Transactions of the "Guernsey society of natural science" for 1915.)
The rainfall and sunshine of Guernsey for the year 1916. cover-title, 8 p. incl. tables. 22½ cm. (Reprinted from the Transactions of the "Guernsey society of natural science" for 1916.)
The rainfall of Guernsey for the year 1914. cover-title, 5 p. incl. 3 tables. 22½ cm. (Reprinted from the Transactions of the "Guernsey society of natural science" for 1914.)
The sunshine of Guernsey for the year 1914. cover-title, 3 p. incl. table. 22½ cm. (Reprinted from the Transactions of the "Guernsey society of natural science" for 1914.)

Great Britain. Meteorological office.
Réseau mondial, 1913. Monthly and annual summaries of pressure, temperature, and precipitation at land stations, generally two for each ten-degree square of latitude and longitude . . . London. 1918. xv, 112 p. incl. tables. 31½ cm. At head of title: Meteorological office. British meteorological and magnetic year book, 1913. Part V. M. O. No. 214g. (Tables.)

Guernsey. Meteorological station.
Observations météorologiques, 1917. Rapport. Guernsey. 1918. cover-title, 16 p. fold. chart. 8 tables. 27½ cm. In French and English. A. Collenette, Observer.

Johnstone, James.
The Gulf Stream and the weather. 25 cm. (Excerpted from the Journal of the Manchester geographical society. vol. 33, parts 1-4. 1917. p. 23-30.) [Describes gulf stream, and shows how cyclones may originate over "islands" of warm water.]

New York central railroad. Office of consulting engineer, rails, tires, and structural steel.
Chart of mild and cold winters. 6th Annual weather issue. New York. 1918. sheet. chart. table. 26½ x 61 cm. At head of title: United States railroad administration . . .

Sutton, J[ohn] R[ichard].
A lunar period in the rates of evaporation and rainfall. 7 tables. 25½ cm. (Excerpted from Transactions of the Royal Society of South Africa, Cape Town. vol. 7, part 1. 1918. p. 103-109.)

Tippenhauer, L[ouis] G[entil].
The dependence of the mean monthly temperature on the earth from the variation of the electromagnetic energy of the sun. Port-au-Prince. 1918. p. 1., [29]-36 p. 28 tables. 2 fold. charts. 30 cm. At head of title: The electromagnetic theory of the weather. Fifth part. (English edition.)
La dépendance de la pluie de la double action du soleil et de la lune. Port-au-Prince. 1918. 9 fold. tables. 2 fold. charts. 26 cm. At head of title: La théorie électromagnétique du temps. Sixième partie. Communication provisoire.

Vaughan, Thomas Wayland.
The temperature of the Florida coral-reef tract. 3 maps. tables. 30 cm. (Excerpted from Carnegie institution of Washington. Dept. of marine biology. Papers. vol. 9. 1918. p. 319-339.) Carnegie institution publication no. 213.

Winchell, A[lexander] N[ewton].
The dustfall of March 9, 1918, by A. N. Winchell and E. R. Miller. cover-title. illus. map. chart. 23½ cm. (Reprinted from the American journal of science. vol. 46. October, 1918. p. 599-609.) [Revised and extended in this issue of the Review, pp. 502-506.]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Air. London. v. 2. April, 1918.
Horner, Donald W. Meteorology in relation to aviation. p. 47-50.

Arkiv för matematik, astronomi och fysik. Stockholm. Band 11. No. 18. 1916.
Akerblom, Filip. Ueber die Beziehungen zwischen Luftdrucksgradient, Wind und Reibung bei stationärer, geradliniger Bewegung. p. 1-19.

Arkiv för matematik, astronomi och fysik. Stockholm. Band 13. 1918.
Lundblad, Ragnar. A theory of the pyrgeometer of Ångström. p. 1-10. (No. 7.)
Ångström, Anders. Determination of the constants of pyrgeometers. p. 10. (No. 8.)

Association of American geographers. Annals. New York. v. 7. 1917.
Henry, Alfred Judson. Memoir of Cleveland Abbe. p. 61-67.

Association of American geographers. Annals. New York. v. 8. 1918.
Ward, Robert DeC[ourcy]. Meteorology and war-flying, some practical suggestions. p. 3-33. [Except for the introduction, this is the same as the article in M. W. R., Dec., 1917, 45:591-600.]

British rainfall. London. v. 57. pt. 1. 1917.
The great rain storm of June 28th, 1917. p. 22-30. [Heaviest 24-hour rainfall ever recorded in British Isles.]
Nash, W. C. The diminution of rainfall with elevation. p. 34-39. [Compares records of several gages at Royal Observatory, Greenwich, up to 50 feet.]

Engineering news-record. New York. v. 81. December 19, 1918.
Electric heaters keep track switches clear of snow and ice. p. 1120.

Great Britain. Meteorological office. Circular. London. no. 30. November 26, 1918.
Pilot balloon observations: the Shoeburyness system. p. 1-2.

National academy of sciences. Proceedings. Washington. v. 4. October. 1918.
Abbot, C[harles] G[reeley]. The Smithsonian solar constant expedition to Calama, Chile. p. 313-316.

Scientific American. New York. v. 119. December 21, 1918.
Carpenter, Ford Ashman. Ice formation over a stream. p. 501.

Scientific monthly. New York. v. 8. January, 1919.
Ward, Robert DeC[ourcy]. Weather controls over the fighting during the autumn of 1918. p. 5-15.

Tokyô mathematico-physical society. Proceedings. Tôkyô. v. 9. November, 1918.
Fujiwhara, Sakuhei. On the theory of the Lowitz's arc and allied phenomena. p. 502-515.
Terada, Torahiko. On the frequency of earthquake and allied phenomena. p. 515-522.

Académie des sciences. Comptes rendus. Paris. Tome 167. 25 novembre 1918.
Bourgeois. Sur une méthode de détermination de la vitesse et de la direction des vents, par temps couvert, à l'aide de sondages par le son. p. 769-772.

Aérophile. Paris. 26 année. 1–15 septembre 1918.
Frantzen, Lucien-Pierre. Cerfs-volants météorologiques. p. 266–267.

Revue du ciel. Bourges. 3 année. Décembre 1918.
Moye, M[arcel]. La scintillation des étoiles. p. 512–513.
Dupaigne, J. Comment on devrait apprécier le vent en climatologie. p. 515–518.

Hemel en dampkring. Den Haag. 16 jaarg. 1918.
Visser, S. W. De draagwijdte van den donder. p. 65–70. (Sept.)
Pinkof, M. De halo van Heemskerk en Barents. p. 70–73. (Sept.) [Description and contemporary drawing of halo observed in 1596.]
C[annegieter], H. G. Richard Assmann. p. 90–92. (Oct.) [Obituary.]

Geografia. Novara. anno 6. Luglio-agosto 1918.
India britannica: ghiacciai artificiali per l'irrigazione dei pascoli e campi alpini. p. 306–307. [Abstract of article by G. Dainelli.]

Società meteorologica italiana. Bollettino bimensuale. Torino. v. 36. Febbraio-marzo-aprile 1917.
Crestani, Giuseppe. Intorno alla formazione delle cappe sui cumuli. p. 9–14.
Oddone, Emilio. La frequenza dei temporali in Val Padana. p. 14–17.

Observatorio meteorologico y sismologico central de Mexico. Boletin mensual Tacubaya. Junio 1917.
Lopez, Elpidio. Estudio sobre "nortes." p. 263–271.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

WEATHER FOR NOVEMBER, 1918.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Jan. 3, 1919.]

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds for November, 1918, are graphically shown on Chart VII, while the means at the several stations, with the departures from the normal, are shown in Tables I and III.

The average barometric pressure for November was slightly above the normal in the Ohio and lower Mississippi Valleys, the Great Plains, and the far Northwest. Elsewhere it was below the seasonal average. The departures were everywhere small. A more detailed discussion of the daily movements of the important cyclones and anticyclones will be found under Forecasts and Warnings.

The general distribution of the barometric pressure favored westerly winds in the northern portion of the country from the Rocky Mountains eastward, northerly in the South Atlantic and east Gulf States, and southerly in the west Gulf and southern Great Plains States. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with generally cool weather in most districts, except in the north Pacific States, where temperatures were above the seasonal average. The line of freezing extended as far south as Fort Smith, Ark., and light frost occurred in the east Gulf States on the morning of the 2d. Toward the middle of the first decade much warmer weather overspread the Plains region and moved slowly eastward, reaching the Atlantic States the latter part of the decade. At the beginning of the second decade temperatures still above the normal obtained in most sections of the country, continuing until after the middle of the month, about which time high temperatures for the season occurred to eastward of the Plains States and along the North Pacific coast. Early in the third decade temperatures somewhat below the seasonal average overspread the central and western districts, and moved slowly eastward, over the northern sections, and the month closed with moderately cold weather for the season in practically all parts of the country. The month as a whole averaged more than 6 degrees a day above the normal in the upper Mississippi Valley and parts of the upper Lakes region, and it was warmer than the normal on the north Pacific coast and in most central and eastern States. It was colder than the average in the Rocky Mountains and Plateau districts and in most of the South.

PRECIPITATION.

At the beginning of November generally fair weather prevailed, except that light rain was falling in the northeastern States, and snow was reported at points in the Lake Superior region and the mountainous portion of Virginia. During the next few days fair weather prevailed east of the Rocky Mountains, except for light rain or snow from the Lakes region eastward. At the same time rain set in over the far Northwest and moved slowly southeastward, overspreading most districts to the Mississippi Valley, and thence over the Great Lakes and to the eastward. Heavy falls occurred in portions of California, and locally in the Missouri Valley, the Gulf States, and Lake region. During the first few days of the second decade fair weather prevailed in practically all districts, except for some rain over the North Pacific coast. However, about the middle of the month general rains occurred in nearly all sections of the country, except in the Eastern States, and during the next several days rather substantial rains occurred from the Mississippi Valley eastward. Early in the third decade there was snow in the central Rocky Mountain and Plains regions, with cloudy, unsettled weather to the eastward, and rain prevailed in the far South during the next few days. About the middle of the decade rain or snow occurred locally over many portions of the Pacific Coast and Plateau regions, and toward the latter part of the decade general rains occurred throughout the Southern States and great central valleys, and snow to the northward, the rainfall being heavy in portions of the East Gulf States. At the close of the month the weather was fair in practically all sections of the country, except for light rain in the far South and Southeast, and light snow locally in the Lake region.

For the month as a whole the precipitation was heavy in much of the Gulf coast section, and substantial amounts fell from northern Oklahoma to the lower Missouri Valley, over much of the Mississippi Valley and Lakes region, and in the northern portion of the Pacific Coast States. From the Ohio Valley, Tennessee, and Virginia northeastward the precipitation was light, as was also the case in the central Rocky Mountain district and western portion of the central Plains States, where it was mostly in the form of snow.

SNOWFALL.

Considerable snow fell during November in the Plains region, from Montana and North Dakota to central Texas, and westward to the Sierra Nevada. In the southern Rocky Mountains the fall was unusually heavy, and on account of the cold weather much remained on the ground at the close of the month. From Oklahoma and Kansas northeastward to the Lakes region there was more or less snow during the latter part of the month, the falls being heavy in northern Michigan, and in northern New York and portions of New England there was likewise considerable snow. (See Chart VIII.)

RELATIVE HUMIDITY.

The relative humidity was above the normal throughout the country, except in the lower Lake region, the far Northwest, and locally along the Atlantic, Gulf, and Pacific coasts, where it was below the seasonal average. Over portions of the central Rocky Mountain region and central Missouri Valley the relative humidity was from 15 to nearly 20 per cent above the normal.

GENERAL SUMMARY.

The weather during the month was favorable for farm work, except in most parts of the South, where frequent rains caused some delay. Much late cotton matured

under the influence of the mild weather and the absence of severe frosts, especially in the western cotton area, and the top crop was larger than expected, although a considerable portion of it was damaged by rain. Harvesting of the crop made satisfactory progress.

The month was exceptionally favorable for winter wheat, the crop started well and was in unusually favorable condition to enter the winter. A larger acreage than usual was reported from nearly all the more important grain-producing States. Other winter grains made satisfactory growth during the month. Truck crops progressed favorably, except there was some injury by frost and heavy rains in the western Gulf region.

The month was generally favorable for pastures, and while the cold rains and snows during the latter part of the month were unfavorable for stock from Texas west to Arizona, yet in most sections it was in uniformly good condition. The weather was favorable for citrus fruit and for saving the apple crop in the North Pacific States.

SEVERE LOCAL STORMS.

The following note of a severe storm has been extracted from the official Weather Bureau report:

Pennsylvania.—On November 17, 1918, between 11:30 p. m. and midnight, during the prevalence of a thunderstorm attended by heavy rain, a tornado swept over Riverside, about 2 miles north of Harrisburg. The tornado moved from southwest to northeast and its path was about 500 feet wide and from 1,500 to 2,000 feet long. One dwelling was overturned, another lifted up and dropped back into its cellar, and about 50 other buildings unroofed or otherwise damaged; loss estimated, $100,000. Two persons were injured.

Average accumulated departures for November, 1918.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	Ins.	Ins.	Ins.	0–10.		P. ct.	
New England	41.4	+2.0	− 6.4	2.43	−1.10	− 5.30	6.3	+0.2	75	−1
Middle Atlantic	45.8	+1.6	− 0.9	1.47	−1.40	− 6.90	5.3	−0.1	72	−2
South Atlantic	54.1	0.0	+ 5.5	2.75	−0.10	−13.50	4.1	−0.3	76	0
Florida Peninsula	71.6	+0.6	+ 6.1	1.35	−0.90	−16.90	4.3	+0.1	76	−4
East Gulf	55.4	−0.3	+ 8.8	4.80	+1.30	+ 2.30	4.7	+0.2	76	+1
West Gulf	55.1	−1.3	+ 6.6	4.49	+1.40	− 6.70	5.6	+0.9	74	+1
Ohio Valley and Tennessee	45.5	+0.7	− 1.0	1.78	−1.70	− 4.80	5.7	+0.1	72	−1
Lower Lakes	42.1	+3.0	− 4.5	1.75	−1.20	− 2.60	7.0	−0.3	74	−2
Upper Lakes	39.3	+5.0	− 3.4	2.81	+0.40	− 2.60	7.0	−0.1	80	0
North Dakota	30.0	+5.4	+16.4	1.16	+0.40	− 3.30	5.6	+0.1	82	+3
Upper Mississippi Valley	42.1	+4.3	+ 5.0	2.10	0.00	− 2.00	5.6	+0.1	75	+1
Missouri Valley	41.0	+4.3	+18.9	2.44	+1.20	− 2.60	4.9	0.0	77	+7
Northern slope	31.8	−0.2	+ 8.9	0.52	−0.20	+ 1.10	4.9	−0.2	71	+2
Middle slope	41.8	0.0	+10.9	1.72	+0.80	+ 1.10	4.3	+0.3	72	+9
Southern slope	48.5	−2.5	+11.1	1.44	+0.90	− 5.70	4.7	+0.3	68	+2
Southern Plateau	46.5	−2.4	− 0.8	0.73	+0.20	0.00	3.2	+0.4	54	+6
Middle Plateau	36.4	−3.1	+ 2.5	0.68	−0.20	− 0.70	4.6	+0.3	61	0
Northern Plateau	38.7	+0.1	+17.6	0.67	−0.90	− 1.90	6.2	+0.1	72	+1
North Pacific	46.6	+1.0	+14.1	4.91	−2.00	− 5.70	7.8	+0.2	85	−1
Middle Pacific	51.6	−1.5	+ 4.7	4.05	+0.90	− 3.30	4.6	−0.1	75	0
South Pacific	57.6	+0.5	+23.0	2.39	+1.20	+ 3.50	3.4	−1.0	67	0

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING NOVEMBER, 1917.

The data presented are for November, 1917, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month.

Chart IX (XLVI–101) shows the averages of pressure, air temperature, water surface temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian Time (Greenwich mean noon).

Notes on the location and courses of the more severe storms of the month are included in the following general summary.

PRESSURE.

The distribution of the mean atmospheric pressure for the month differed from the normal in several respects. The Azores or North Atlantic HIGH was considerably greater in intensity than usual, and about 1,000 miles northeast of its usual position. The Icelandic LOW, with its center between Iceland and the Scandinavian Peninsula, was well developed, and there was a second LOW central near latitude 52°, longitude 48°. The following table gives for a number of selected 5-degree squares the average pressure for each of the three decades of the month, as well as the highest and lowest individual readings reported during the month within the respective squares.

Pressure over North Atlantic Ocean during November, 1917, by 5-degree squares.

Position of 5-degree squares.		Decade means.			Extremes.			
					Highest.		Lowest.	
Latitude.	Longitude.	I.	II.	III.*	Pressure.	Date.	Pressure.	Date.
°	°	Inches.	Inches.	Inches.	Inches.	November.	Inches.	November.
60–65 N	20–25 W	29.85	29.86	29.73	30.23	2	29.46	29
60–65 N	0– 5 E	29.62	29.88	29.38	30.30	3	29.00	27
55–60 N	35–40 W	29.87	29.72	29.80	30.16	2	29.42	10
55–60 N	10–15 W	29.77	30.03	29.80	30.30	15	29.30	9
50–55 N	55–60 W	29.88	29.68	29.86	30.42	5	29.30	10
50–55 N	25–30 W	29.97	29.93	30.05	30.40	22	29.61	29
50–55 N	0– 5 W	29.81	30.34	30.03	30.51	18	29.27	9
45–50 N	65–70 W	30.08	29.90	30.02	30.50	4, 27	29.50	24
45–50 N	40–45 W	30.00	29.77	29.96	30.32	23	29.49	13
45–50 N	10–15 W	30.03	30.39	30.39	30.53	23	29.84	10
40–45 N	50–55 W	29.98	29.80	29.90	30.30	5	29.59	14
40–45 N	25–30 W	30.19	30.23	30.42	30.55	25	29.68	1
35–40 N	75–80 W	30.31	30.09	30.05	30.62	25	29.46	22
35–40 N	35–40 W	30.20	30.17	30.34	30.52	24	29.95	2
35–40 N	10–15 W	30.24	30.35	30.42	30.53	26	30.15	2
30–35 N	50–55 W	30.07	30.07	30.15	30.25	23	29.90	7
30–35 N	25–30 W	30.24	30.31	30.38	30.50	23	29.80	1
25–30 N	90–95 W	30.28	30.17	30.13	30.40	2	29.95	22
25–30 N	60–65 W	30.06	30.05	30.08	30.28	28	29.98	24
25–30 N	15–20 W	30.24	30.23	30.27	30.41	10	30.08	2
20–25 N	75–80 W	30.00	30.01	30.06	30.25	27	29.90	6
20–25 N	50–55 W	30.00	30.08	30.11	30.20	20, 23	29.90	7
15–20 N	35–40 W	30.01	30.08	30.06	30.18	23	29.89	1
10–15 N	80–85 W	29.88	29.90	29.93	29.98	24, 27	29.80	7

* The mean values presented in the above table are based on the interpolated daily pressure for each square on the daily synoptic charts of the North Atlantic, compiled by the marine section of the Weather Bureau. The extremes are the highest and lowest actual readings observed within the respective squares.

GALES.

The number of days on which gales occurred was considerably below the normal over the entire ocean, with the exception of a small area in the vicinity of the south coast of Florida, where they were slightly more numerous than usual.

On the 2d and 3d a LOW of moderate intensity surrounded the Azores, although only light to moderate

winds were reported from that locality. On the 3d a HIGH, with a crest of 30.40 inches, extended along the American coast between Hatteras and northern Florida, and vessels in the easterly and southerly quadrants encountered gales of from 50 to 55 miles an hour. On the 4th the crest of the HIGH was near Montreal, where the barometric reading was 30.66 inches. At the same time a LOW of 29.86 inches surrounded Bermuda, and moderate northeasterly gales still prevailed over the same territory as on the previous day.

On the 5th a LOW of 29.86 inches covered a limited area between the Isthmus of Panama and Cuba, and winds of gale force were observed by a few vessels in the eastern part of the Gulf of Mexico, as well as in Cuban waters, although a number of reports were received from vessels in that region that experienced only light to moderate winds. On the 6th an area of low pressure covered the eastern part of the Gulf of St. Lawrence, and moderate southwesterly gales occurred over the Banks of Newfoundland. From the 9th to the 14th this LOW remained nearly stationary, but no heavy winds were reported during that period.

On the 14th a slight depression (I on Chart IX) was central about 150 miles east of Charleston, S. C. Low I drifted slowly northeastward parallel with the coast, and on the 15th the center was about 120 miles south of Hatteras, where moderate winds were the rule. The disturbance continued in its northeasterly course, being central on the 16th near Halifax, N. S., where the barometer reading was 29.56 inches. One vessel a short distance south of St. Johns, N. F., encountered a moderate southeasterly gale, while over the greater part of the territory between the 50th meridian and the North American coast moderate weather prevailed. During the next 24 hours the movement of the LOW was slight, as on the 17th the center was at Sydney, C. B. I., the conditions of wind and weather remaining about the same as on the 16th.

From the 19th to the 28th there was a LOW of varying intensity in the vicinity of the Scandinavian Peninsula and the North Sea. Moderate to strong gales were recorded on a number of days during this period between the 15th meridian and the European coast, although it was impossible to determine the conditions accurately, due to lack of sufficient observations.

On the 22d a LOW (II on Chart IX) covered that part of the American coast between Hatteras and New York, where light to moderate winds prevailed. This disturbance pursued a course similar to that of Low I, and on the 23d the center was a short distance east of New York, wind and weather remaining about the same as on the previous day. By the 24th the center of this depression had reached Halifax, moderate weather still continuing along the North American coast. Low II then curved sharply toward the east, increasing its rate of translation, and on the 25th the center was in the vicinity of St. Johns, N. F. No heavy winds were encountered, but hail was reported off the New Jersey coast, and snow and fog between latitude 40°-45°, longitude 45°-50°. During the 26th and 27th this LOW apparently remained in the same position as on the 25th, increasing somewhat in extent, but it was impossible to plot its center accurately, on account of lack of observations. On the 26th one vessel about 200 miles east of the Virginia coast reported a moderate northwesterly gale, with hail and snow, while hail and snow prevailed off the coast of Nova Scotia also, and fog was observed near latitude 43°, logitude 51°. The conditions on the 27th were about the same as on the day before, with the exception that no fog was reported on that date. On the 29th there was a well-developed LOW of limited extent central near latitude 41°, longitude 60°, and strong northwesterly gales were encountered in the southwesterly quadrants and hail was reported near the center.

AIR TEMPERATURES.

The average monthly temperature of the air was considerably above the normal over the greater part of the ocean, especially north of the 40th parallel, and in the northern part of the Gulf of Mexico, where large positive departures were the rule. South of the 35th parallel the temperatures were nearly normal, while in the southern division of the Gulf of Mexico the departures were very irregular, varying from +4° in the west to −2° in the east. The seasonal fall in temperature was marked in northern waters, as in several 5-degree squares the monthly mean was 3° to 4° below the average for the first decade. The fluctuations from day to day also were marked, and in the square that includes the east coast of Labrador the temperature ranged from 32° on the 28th to 50° on the 7th.

The following table gives the temperature departures at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coasts:

	°F.		°F.
St. Johns, N. F.	+2.8	Norfolk, Va.	−3.4
Sydney, C. B. I.	+0.9	Hatteras, N. C.	−5.3
Halifax, N. S.	−1.7	Charleston, S. C.	−3.7
Eastport, Me.	−4.4	Key West, Fla.	−4.0
Portland, Me.	−3.0	Tampa, Fla.	−2.6
Boston, Mass.	−1.8	Mobile, Ala.	−0.9
Nantucket, Mass.	−5.0	New Orleans, La.	−1.6
Block Island, R. I.	−5.0	Galveston, Tex.	−0.3
New York, N. Y.	−2.8	Corpus Christi, Tex.	+3.0

WATER-SURFACE TEMPERATURE.

The average water surface temperature did not differ as much from the normal as that of the air. Off the banks of Newfoundland and in some portions of the steamer lanes positive departures of from 2° to 4° prevailed, while in the waters adjacent to the American

and European coasts they were irregular, varying from $-2°$ to $+2°$. In the Gulf of Mexico the water temperatures were from 2° to 3° lower than usual, while in the southeastern division of the ocean they were practically normal.

The seasonal fall in water temperature was not as marked as that of the air, although perceptible in northern waters. The daily fluctuation also was comparatively slight, as the greatest monthly range for any 5-degree square was not over 12°.

HAIL AND SNOW.

Fog was not reported on more than two days in any one 5-degree square, and it was much below the normal over the steamer lanes also, although so few vessel reports were received from the eastern division that it was impossible to give the conditions accurately.

FOG.

Hail and snow occurred on from one to two days over the western portion of the steamer routes, but none was reported from the central and eastern sections.

Winds of 50 mis./hr. (22.4 m./sec.) or over, during November, 1918.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
Block Island, R. I.	26	59	nw.	North Head, Wash.	2	54	se.
Do	30	54	nw.	Do	8	66	s.
Buffalo, N. Y	19	50	sw	Do	9	84	se.
Do	24	56	sw.	Do	10	88	se.
Do	25	56	sw.	Do	13	60	s.
Do	28	66	sw.	Do	14	66	se.
Do	29	76	sw.	Do	15	52	s.
Do	30	76	sw.	Do	26	54	nw.
Chicago, Ill	28	50	sw	Pensacola, Fla	28	61	sw.
Cleveland, Ohio	30	52	w.	Pittsburgh, Pa	28	50	sw.
Dayton, Ohio	28	51	w.	Point Reyes Light, Cal	3	58	s.
Detroit, Mich	28	60	sw.	Do	14	58	sw.
Duluth, Minn	17	53	nw.	Do	17	73	se.
Do	18	53	w.	Do	18	60	se.
Eastport, Me	18	64	e.	Do	23	68	nw.
Do	19	67	e.	Do	24	61	nw.
Ellendale, N. Dak	17	58	nw.	Do	27	56	ne.
Erie, Pa	28	60	se.	Providence, R. I	30	51	nw.
Do	29	55	sw.	St. Louis, Mo	28	52	sw.
Do	30	60	w.	Sandusky, Ohio	28	54	sw.
Grand Haven, Mich	28	51	w.	Sandy Hook, N. J	18	52	s.
Louisville, Ky	28	50	sw.	Tatoosh Island, Wash	9	57	s.
Mount Tamalpais Cal	3	60	se.	Do	13	73	s.
Do	23	52	s.	Do	22	60	e.
Do	25	50	nw.	Do	23	62	e.
Do	27	53	n.	Do	26	57	nw.
New York, N. Y	18	51	w.	Toledo, Ohio	28	64	sw.
Do	26	52	nw.				
Do	30	55	nw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November, 1918.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	53.0	−0.8	2 stations	81	5†	2 stations	25	30	4.94	+2.02	Ozark	8.64	Scottsboro	0.92
Arizona	48.2	−3.1	Mohawk	98	1	Lakeside	−7	30	1.48	+0.74	Fort Apache	5.70	Yuma	0.07
Arkansas	49.7	−1.5	Huttig	88	6	Gravette	18	30	3.91	+0.43	Marked Tree	6.13	Marianna	1.60
California	50.5	−2.4	Elsinore	98	1	Madeline	−8	27	3.10	+0.29	Kentfield	9.23	Bagdad	0.00
Colorado	30.8	−4.5	Canon City	89	15	2 stations	−25	26†	1.10	+0.35	Cumbres	4.99	Two Buttes Reservoir.	0.02
Florida	64.8	−0.4	3 stations	90	29†	Fenholloway	29	14	3.45	+1.62	Marianna	11.43	Ritta	0.20
Georgia	54.2	−0.1	Brunswick	86	17	Ramhurst	25	25	4.60	+1.97	Blakely	7.84	Ramhurst	2.36
Hawaii (October)	74.8	+1.2	Mahukona	94	9†	Volcano Observatory	52	15	3.98	−0.94	Wahiawa Mountain	14.36	4 stations	0.00
Idaho	34.4	−1.3	2 stations	68	4†	Stanley	−15	24	0.97	−1.26	Wallace	4.16	Challis	T.
Illinois	43.0	+1.2	Carbondale	76	6	Morrison	13	26	2.28	−0.24	Havana	3.37	Walnut	1.28
Indiana	43.0	+0.9	Bedford	77	6	Valparaiso	11	24	2.24	−0.99	Kokomo	5.06	Evansville	0.98
Iowa	39.9	+4.9	6 stations	76	6	Mason City	0	25	2.11	+0.60	Northwood	5.10	Cedar Rapids	0.70
Kansas	42.8	−1.5	St. Francis	81	4	Tribune	2	26	1.82	+0.70	Grenola	6.35	Garden City	0.12
Kentucky	46.1	0.0	Earlington	77	6	2 stations	19	26†	1.90	−1.45	Eubank	3.78	Louisa	1.00
Louisiana	57.0	−1.6	Reserve	92	4	2 stations	27	24	5.46	+1.99	Lake Charles	10.18	Burrwood	2.31
Maryland-Delaware	44.9	+0.5	Denton, Md	74	17	Oakland, Md	13	12	1.44	−0.67	Emmitsburg, Md	3.18	Western Port, Md	0.31
Michigan	99.5	+3.3	2 stations	69	6†	Humboldt	−3	26	3.11	+0.58	Marquette	5.29	St. Joseph	1.39
Minnesota	34.6	+5.3	Wheaton	76	5	Itasca State Park	−6	27	2.24	+1.31	Minneapolis No. 1	4.60	Meadow Lands	0.31
Mississippi	53.4	−2.0	Yazoo City	88	15	3 stations	25	24†	4.27	+1.14	Woodville	8.33	Batesville	1.80
Missouri	44.9	+0.5	Macon	85	6	Maryville	12	30	3.18	+0.79	Dean	8.02	Conception	1.74
Montana	30.6	−1.9	Dillon	76	2	Busby	−22	24	0.72	−0.20	Springbrook	3.19	2 stations	0.00
Nebraska	38.2	+1.6	Fort Robinson	80	2	Kimball	−10	24	1.16	+0.48	Ord	4.18	Lodgepole	T.
Nevada	37.7.	−2.3	Logandale	87	3	Potts	−12	28	0.57	−0.12	Marlette Lake	2.46	2 stations	T.
New England	38.9	+1.8	Rutland, Vt	70	18	Patten, Me	−2	29	2.77	−0.60	Millinocket, Me	5.25	Boston, Mass	1.20
New Jersey	43.9	+1.1	2 stations	71	8	Culvers Lake	10	27	1.87	−1.55	Charlotteburg	3.05	Atlantic City	0.49
New Mexico	38.4	−4.0	Deming	91	1†	Dulce	−18	30	1.18	+0.50	Mogollon, R. S	4.22	Lordsburg	0.10
New York	40.1	+2.6	Wedgwood	71	7	3 stations	2	26	2.26	−0.55	Dannemora	5.58	Romulus	0.67
North Carolina	49.3	+0.2	Goldsboro	82	17	Jefferson	18	12†	2.40	−0.23	Rock House	5.66	Altapass	0.48
North Dakota	28.9	+2.3	3 stations	69	4†	Bowman	−16	24	1.00	+0.42	Minot	2.62	Dickinson	0.10
Ohio	42.3	+1.1	2 stations	75	6†	Peebles	12	26	2.02	−0.60	Brilliant	3.76	West Manchester	1.00
Oklahoma	48.0	−2.3	Durant	82	7	Kenton	8	23	2.87	+0.77	Hugo	8.44	Buffalo	0.40
Oregon	40.3	−3.0	2 stations	70	1†	2 stations	−10	25†	3.01	−3.08	Toledo	10.30	Bear Valley	0.10
Pennsylvania	42.1	+1.6	Brookville	76	16	Milford	11	27	2.03	−0.90	Grove City	4.07	Hyndman	0.44
Porto Rico	76.5	−0.2	2 stations	96	4†	Laraes	57	24†	8.01	+0.10	Toro Negro Dam	16.09	Dorado	3.07
South Carolina	53.0	−0.7	2 stations	86	16†	Bowman	26	14	3.13	+0.85	Paris Island	5.89	Centenary	1.33
South Dakota	34.2	+2.2	Wagner	80	7	Bellefourche	−20	24	1.09	+1.06	Castlewood	4.92	Orman	0.07
Tennessee	47.6	−0.7	Savannah	79	5	Erasmus	15	30	2.43	−1.09	Sewanee	5.22	Johnson City	1.03
Texas	54.2	−2.9	Fort Stockton	92	2	Dalhart	7	29†	4.42	+2.23	Stephenville	18.08	Jayton	0.23
Utah	33.8	−3.6	Springdale	85	2	Blacks Fork	−25	23	0.98	−0.07	Silver Lake	4.57	Lemay	0.00
Virginia	46.4	−0.2	2 stations	79	8	Burkes Garden	15	12	1.54	−0.77	Mount Weather	4.08	Onley	0.18
Washington	40.6	+0.8	Wahluke	70	1	Wilbur	0	26	3.43	−1.55	Forks	14.05	Attalia	0.27
West Virginia	42.9	+0.2	2 stations	79	17	Sutton	12	26	1.89	−0.55	Camden-on-Gauley	4.60	Wardensville	0.64
Wisconsin	36.9	+4.5	Cecil	72	7	Koepenick	0	30	2.23	+0.45	Downing	3.72	Muscoda	0.75
Wyoming	28.3	−3.7	Wheatland	76	3	Sheridan Field Sta	−22	24	0.60	−0.01	Cody	1.81	Hyattville	0.03

†Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

(*See* the REVIEW, January, 1918, p. 48.)

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1918.*

Districts and stations.	Elevation of instruments: Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Departure from normal.	Days with .01 inch or more.	Wind: Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England.							**41.4**	**+2.0**										**75**	**2.43**	**-1.1**										**6.3**		
Eastport	76	67	85	29.87	29.96	-0.05	37.6	+0.8	53	10	43	16	27	32	19	35	32	81	2.00	-2.1	10	8,937	nw.	67	e.	19	7	8	15	6.6	0.1	0.1
Greenville, Me.	1,070	6		28.78	29.97		32.6		51	1	38	8	26	27	22				3.77		16						6	4	20		5.2	
Portland, Me.	103	82	117	29.89	30.02	-.02	39.7	+2.1	56	1	46	17	27	33	24	36	31	73	3.38	-0.4	13	6,050	w.	36	nw.	26	8	11	11	5.5		
Concord	288	70	79	29.69	30.01	-.05	39.2	+2.4	58	15	47	13	27	31	34				2.34	-1.0	10	3,525	nw.	24	nw.	26	7	9	14	6.1	0.2	
Burlington	404	11	48	29.55	30.00	-.05	36.6	-0.2	63	18	43	14	26	30	23				4.53	+2.0	12	8,465	s.	46	s.	9	3	8	19	7.7	0.5	0.4
Northfield	876	12	60	29.04	30.01	-.04	34.4	+2.4	57	18	42	4	27	26	33	32	29	82	2.25	-0.4	12	4,985	s.	28	s.	9	2	10	18	7.9	2.0	0.8
Boston	125	115	188	29.86	30.00	-.05	45.0	+3.8	65	18	52	19	26	39	22	40	34	71	1.20	-2.9	9	7,125	w.	29	sw.	18	7	11	12	6.1	T.	
Nantucket	12	14	90	29.99	30.00	-.05	46.0	+0.8	61	16	51	23	26	41	18	42	37	73	1.53	-1.8	9	11,980	nw.	47	sw.	18	9	9	12	6.0		
Block Island	26	11	46	29.98	30.02	-.04	46.0	+0.7	61	18	43	24	26	40	17	43	40	80	1.37	-2.5	6	15,061	nw.	59	nw.	26	5	11	14	6.6		
Providence	160	215	251	29.84	30.01	-.06	43.2	+2.8	63	18	50	19	26	36	24	38	33	71	2.01	-1.9	7	9,059	nw.	51	nw.	30	7	14	9	5.7	T.	
Hartford	159	122	140	29.85	30.03	-.05	43.0	+3.5	64	8	50	20	26	35	31	38	33	73	2.74	-1.1	10	5,167	nw.	37	w.	30	7	10	13	6.0	T.	
New Haven	106	117	155	29.92	30.04	-.03	44.4	+3.1	64	8	52	24	26	37	26	39	33	70	3.37	-0.2	9	6,413	ne.	31	nw.	30	10	9	11	5.1	T.	
Middle Atlantic States.							**45.8**	**+1.6**										**72**	**1.47**	**-1.4**										**5:3**		
Albany	97	102	115	29.92	30.02	-.06	42.3	+3.9	63	18	49	18	26	36	22	38	33	72	2.54	-0.3	8	4,785	s.	32	s.	28	5	8	17	6.7	T.	
Binghamton	871	10	69	29.08	30.03	-.06	41.7	+4.1	65	17	49	21	26	34	33				1.56	-0.7	8	4,096	sw.	24	nw.	26	7	6	17	7.1	0.2	T.
New York	314	414	454	29.70	30.05	-.04	45.7	+1.7	65	18	52	27	27	40	20	40	33	66	2.04	-1.4	7	13,250	nw.	55	nw.	30	10	9	11	5.6		
Harrisburg	374	94	104	29.68	30.09	-.02	44.0	+2.3	66	8	51	27	24	37	26	39	33	70	1.45	-0.9	5	4,667	w.	38	sw.	17	13	6	11	5.2		
Philadelphia	117	123	190	29.94	30.07	-.03	47.6	+2.7	67	8	54	29	24	41	23	43	40	78	1.93	-1.1	5	7,219	nw.	28	ne.	5	12	7	11	5.0		
Reading	325	81	98	29.73	30.09		44.2		68	17	52	26	27	37	28	38	33	69	1.79	-1.3	6	4,875	nw.	25	nw.	30	12	7	11	5.4		
Scranton	805	111	119	29.18	30.06	-.03	42.4	+3.3	65	17	50	22	27	35	29	39	37	86	1.04	-1.2	6	4,905	sw.	29	s.	18	9	7	14	6.2	T.	
Atlantic City	52	37	48	30.01	30.07	-.03	46.6	+1.1	62	17	53	27	24	40	23	42	38	76	0.49	-2.7	5	5,584	nw.	29	se.	28	13	7	10	4.7		
Cape May	18	13	49	30.07	30.09	-.01	47.6	+0.2	64	18	54	29	24	42	22	43			0.73	-2.5	7	7,097	nw.	40	se.	38	12	10	8	4.9		
Sandy Hook	22	10	57	30.03	30.05		46.4		63	18	51	30	27	42	19	41	36	70	1.37		6	12,852	w.	52	s.	18	11	8	11	5.4		
Trenton	190	159	183	29.84	30.05		44.8		66	18	52	26	27	38	27	40	35	72	1.85	-1.6	5	8,161	w.	38	w.	30	12	7	11	5.4		
Baltimore	123	100	113	29.96	30.09	-.02	47.2	+1.4	69	8	55	28	24	40	25	41	35	67	1.50	-1.4	5	4,088	sw.	21	n.	5	14	5	11	4.7		
Washington	112	62	85	29.96	30.09	-.03	46.3	+1.3	72	8	55	25	24	38	35	40	34	69	1.48	-1.2	4	4,484	nw.	25	nw.	10	13	8	9	4.7		
Lynchburg	681	153	188	29.35	30.11	-.02	46.8	+0.7	74	8	58	25	13	36	41	39	34	69	1.26	-1.5	3	4,736	n.	28	nw.	20	17	5	8	4.6		
Norfolk	91	170	205	29.99	30.09	-.02	52.0	+0.8	75	17	58	35	25	46	26	46	41	71	0.77	-2.0	2	9,501	n.	38	s.	18	12	8	10	4.8		
Richmond	144	11	52	29.95	30.11	-.01	47.8	-1.0	75	17	58	26	24	38	38	41	36	71	1.26	-1.1	4	5,216	sw.	46	sw.	18	13	8	9	4.7		
Wytheville	2,203	49	55	27.69	30.12	-.01	42.5	-0.5	69	8	52	23	12	33	37	36	32	73	1.14	-1.9	6	4,542	w.	28	sw.	18	16	4	10	4.3		
South Atlantic States.							**54.1**	**0.0**										**76**	**2.75**	**-0.1**										**4.1**		
Asheville	2,255	70	84	27.74	30.14	.00	46.2	+1.1	72	8	56	28	25	37	37	39	35	73	1.78	-1.5	7	6,422	nw.	33	s.	17	16	6	8	4.3	0.1	
Charlotte	773	153	161	29.26	30.11	-.02	50.7	+0.3	75	17	60	31	25	42	29	44	39	73	3.23	+0.4	5	3,422	ne.	23	sw.	18	14	9	7	4.0		
Hatteras	11	12	50				56.2	-0.5	73	17	62	42	24	51	22	52	50	82	2.30	-2.4	7	11,432	n.	48	s.	18	12	8	10			
Manteo	12	4	46				52.9		70	17	60	32	24	46					1.96		4		n.				15	4	11			
Raleigh	376	103	110	29.70	30.11	-.02	51.4	+1.2	78	17	61	32	24	42	31	44	39	69	1.66	-0.7	5	5,471	ne.	29	sw.	17	15	6	9	4.2		
Wilmington	78	81	91	30.02	30.10	-.02	54.4	+0.3	77	17	63	37	8	45	34	47	43	76	2.62	+0.2	8	5,226	n.	28	sw.	18	15	9	6	4.2		
Charleston	48	11	92	30.04	30.10	-.02	56.6	-1.5	77	16	64	42	13	49	22	50	46	74	2.34	-0.5	8	7,553	n.	31	n.	24	18	2	10	3.9		
Columbia, S. C.	351	41	57	29.73	30.12	.00	53.2	-0.6	79	17	63	33	25	43	33	46	41	72	2.15	-0.1	7	4,850	ne.	30	sw.	18	15	6	9	4.1		
Greenville, S. C.	1,013	113	122	28.99	30.10		50.6		69	4	59	33	13	42	27	44	40	73	3.18		8	4,976	ne.	35	sw.	17	14	8	8	3.9	0.3	
Augusta	180	62	77	29.91	30.11	-.02	54.6	+0.7	80	17	65	35	14	45	35	48	46	82	3.51	+0.6	9	3,983	nw.	25	w.	19	15	5	10	4.4		
Savannah	65	150	194	30.03	30.10	-.02	57.0	-0.5	79	17	65	41	13	48	26	50	46	76	4.66	+2.3	9	7,138	ne.	33	w.	19	17	3	10	4.2		
Jacksonville	43	200	245	30.03	30.08	-.02	60.4	-0.9	78	17	68	42	13	53	21	55	52	81	3.26	+1.1	7	9,437	n.	37	sw.	18	16	3	11	4.1		
Florida Peninsula.							**71.6**	**+0.6**										**76**	**1.35**	**-0.9**										**4.3**		
Key West	22	10	64	29.99	30.01	-0.01	75.4	+1.1	86	29	80	62	21	71	14	68	66	77	0.38	-2.0	4	8,042	ne.	30	nw.	18	15	12	3	3.6		
Miami	25	71	79	30.00	30.03		72.2	+0.2	82	29	78	54	21	66	20	67	64	78	0.60	-2.0	7	6,738	ne.	25	ne.	7	11	15	4	4.5		
Tampa	35	79	92	30.02	30.06	-.02	67.2	+0.4	83	16	76	48	21	58	29	59	55	74	3.07	+1.4	6	5,105	ne.	24	n.	3	12	10	8	4.8		
East Gulf States.							**55.4**	**-0.3**										**76**	**4.80**	**+1.3**										**4.7**		
Atlanta	1,174	190	216	28.86	30.12	-0.01	51.6	-0.3	71	17	60	33	25	44	23	45	40	72	3.68	+0.3	9	7,909	nw.	35	se.	28	15	5	10	4.3		
Macon	370	78	87	29.71	30.12	-.01	53.3	0.0	75	17	63	33	14	44	35	47	42	76	4.31	+1.2	11	4,151	ne.	25	s.	17	14	6	10	4.4		
Thomasville	273	49	58	29.79	30.09	-.03	57.8	-0.7	79	17	68	38	13	48	31	50	45	71	5.38	+2.7	11	3,400	ne.	20	sw.	17	15	5	10	4.5		
Pensacola	56	149	185	30.02	30.08	-.03	59.4	-0.2	75	16	66	45	23	53	23	54	52	82	4.58	+0.8	11	9,762	ne.	61	sw.	28	13	5	12	5.0		
Anniston	741	9	57	29.33	30.14	+.02	50.9	-1.0	74	17	62	31	25	40	39				3.87	+0.5	12	3,719	se.	27	sw.	17	17	3	10	4.2		
Birmingham	700	11	48	29.35	30.13	+.01	52.4	-1.7	74	5	62	32	25	43	32	45	40	72	5.25	+1.9	13	4,495	n.	34	se.	17	14	7	9	4.2		
Mobile	57	125	161	30.03	30.09	-.02	59.0	+1.5	78	5	67	41	23	51	26	52	49	77	7.14	+3.4	12	7,381	n.	39	s.	15	10	11	9	5.0		
Montgomery	223	100	112	29.87	30.12	.00	55.6	-0.1	77	16	64	41	25	47	28	49	45	75	6.08	+3.0	10	4,588	n.	30	s.	28	14	7	9	4.7		
Corinth	469	6					50.2		78	5	62	26	30	39	39				2.22		9		n.				14	6	10			
Jackson	304	5					54.2		82	8	66	32	24	43	42				3.45		10		se.				16	8	6			
Meridian	375	85	93	29.70	30.11	-.01	53.2	0.0	75	16	63	33	25	43	32	47	45	81	4.23	+0.1	10	3,723	ne.	33	sw.	28	13	8	9	4.8		
Vicksburg	247	65	74	29.84	30.13	+.01	54.2	-1.7	78	8	63	32	24	45	30	48	44	77	3.85	-0.3	11	5,002	se.	33	w.	17	12	4	14	5.6		
New Orleans	51	76	84	30.02	30.08	-.02	61.7	+1.1	81	16	69	44	23	55	24	56	53	81	4.46	+0.7	7	5,370	ne.	24	ne.	25	13	9	8	4.8		
West Gulf States.							**55.1**	**-1.3**										**74**	**4.49**	**+1.4**										**5.6**		
Shreveport	249	77	93	29.84	30.12	+.01	54.1	-1.2	80	6	63	30	24	46	30	47	43	73	4.13	0.0	9	5,554	se.	32	se.	20	14	5	11	4.9		
Bentonville	1,303	11	44	28.70	30.09	-.02	46.4	-0.3	74	6	56	22	30	37	34				3.87	+0.9	10	4,155	nw.	28	w.	17	15	2	13	5.0	1.0	
Fort Smith	457	79	94	29.60	30.09	-.02	50.7	+0.8	76	6	59	29	24	43	29	44	39	71	3.58	+0.3	9	5,826	e.	37	w.	17	13	2	15	5.5	T.	
Little Rock	357	139	147	29.73	30.11	-.01	51.0	-0.5	76	6	58	32	23	44	29	45	40	71	3.11	-1.5	6	5,874	n.	34	w.	17	16	3	11	4.6		
Brownsville	57	4	26				65.8		91	16	74	37	24	57	36				2.16		9		n.									
Corpus Christi	20	69	77	30.06	30.08	+.01	62.6	-0.8	83	15	68	36	28	57	28	57	55	80	2.38	0.0	11	7,525	n.	27	n.	30	7	5	18	6.9		
Dallas	512	109	117	29.52	30.08		53.3		78	6	61	30	24	46	28				8.32		8	6,168	se.	32	nw.	17	12	7	11	5.2	0.6	
Fort Worth	670	106	114	29.36	30.08	-.02	53.6	-1.5	78	6	61	31	26	46	28	48	44	75	7.94	+6.4	8	7,424	se.	32	s.	7	11	7	12	5.4	T.	
Galveston	54	106	114	30.03	30.09	.00	60.9	-2.0	78	8	65	39	24	57	20	56	52	78	8.15	+4.1	8	8,584	n.	34	ne.	25	9	4	17	6.4		
Houston	138	111	121	29.94	30.09		59.2	-2.1	83	8	66	34	24	52	23				6.02		12	6,403	se.	31	se.	7	10	4	16	5.9		
Palestine	510	64	72	29.56	30.10	-.01	54.7	-2.2	79	7	62	29	24	47	27	48	43	74	4.98	+1.4	8	5,630	ne.	28	w.	17	11	7	12	5.5		
Port Arthur	34	58	66	30.03	30.07		58.2		79	8	64	35	24	52	22	53	50	81	10.43		10	7,337	ne.	36	s.	15	10	7	13	5.7		
San Antonio	701	119	132	29.35	30.08	.00	57.4	-1.8	81	7	65	30	28	40	32	51	46	74	2.53	+0.8	10	6,220	n.	25	nw.	20	7	9	14	6.1	T.	
Taylor	582	55	63	29.49	30.11	+.03	55.0	-2.7	81	7	63	28	24	57	29				4.22	+1.6	8	6,500	n.	29	se.	7	8	9	13	6.3	T.	

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1918*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Total.	Departure from normal.	Days with .01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.	Ft.	Ft.	Ft.	In.	In.	In.	°F. 45.5	°F. + 0.7	°F		°F	°F.		°F	°F.	°F.	°F.	% 72	In. 1.78	In. – 1.7		Miles								0–10 5.7	In.	In.
Chattanooga	762	189	213	29.31	30.14	.00	50.0	– 0.3	72	4	58	32	25	42	31	43	38	70	2.86	– 0.7	7	5,103	nw.	48	sw.	17	14	8	8	4.4	.....	.....
Knoxville	996	102	111	29.05	30.12	– .01	48.6	+ 1.5	71	17	57	32	25	40	28	42	37	72	1.99	– 1.6	7	4,147	ne.	40	sw.	17	11	10	9	5.2	T.	.....
Memphis	399	76	97	29.72	30.15	+ .03	51.0	– 0.4	75	5	58	30	24	44	23	44	38	67	2.75	– 1.8	10	5,712	n.	44	sw.	28	16	1	13	4.7	.....	.....
Nashville	546	168	191	29.55	30.14	+ .02	48.0	– 0.7	70	8	57	29	30	39	32	41	35	67	1.36	– 2.5	7	6,433	w.	41	s.	16	13	9	8	4.6	.....	.....
Lexington	989	193	230	29.02	30.13	+ .01	44.2	– 0.5	68	16	51	24	25	37	27	.....	.....	.....	2.24	– 1.2	6	9,404	w.	48	sw.	28	11	6	13	5.4	.....	.....
Louisville	525	219	255	29.54	30.13	+ .01	46.2	– 0.1	70	16	54	28	25	39	28	40	34	68	1.19	– 3.0	6	8,389	w.	50	sw.	28	10	6	14	5.6	.....	.....
Evansville	431	139	175	29.64	30.12	.00	47.2	+ 1.9	72	6	54	28	25	40	29	41	35	68	0.98	– 3.1	7	8,227	nw.	49	sw.	28	14	4	12	4.6	.....	.....
Indianapolis	822	194	230	29.18	30.09	– .01	43.2	+ 1.6	69	6	50	23	25	36	29	38	34	73	1.73	– 1.8	7	9,170	w.	42	sw.	28	9	5	16	6.3	T.	.....
Terre Haute	575	96	129	29.45	30.08	.....	44.2	.....	70	6	52	23	25	37	28	39	34	73	1.63	.....	7	7,252	nw.	48	sw.	28	12	6	12	5.5	T.	.....
Cincinnati	628	11	51	29.42	30.12	.00	43.4	+ 3.8	67	17	51	22	26	36	32	38	33	73	1.65	– 1.6	8	5,760	sw.	36	sw.	28	11	2	17	6.0	T.	.....
Columbus	824	173	222	29.20	30.10	– .01	42.8	+ 1.4	66	17	50	22	25	36	26	38	33	73	1.24	– 1.9	8	8,753	w.	44	sw.	28	10	5	15	6.0	T.	.....
Dayton	899	181	216	29.09	30.06	.....	43.2	+ 1.1	66	17	50	23	25	36	26	38	34	74	1.67	– 1.2	7	7,690	w.	51	w.	28	11	4	15	6.0	.....	.....
Pittsburgh	842	353	410	29.16	30.08	– .02	43.8	+ 0.9	67	7	51	27	25	37	27	39	34	74	1.79	– 0.8	8	7,683	w.	50	sw.	28	6	5	19	7.1	T.	.....
Elkins	1,940	41	50	28.0[illegible]	30.14	+ .02	40.6	– 2.3	74	8	51	19	12	30	44	31	30	78	1.60	– 1.3	7	4,135	w.	26	w.	17	6	9	15	6.9	T.	.....
Parkersburg	638	77	84	29.45	30.12	.00	44.2	+ 1.0	69	28	53	22	26	36	35	38	34	75	1.85	– 1.0	7	3,756	sw.	26	sw.	29	10	5	15	6.5	T.	.....
Lower Lake Region.							42.1	+3.0										74	1.75	–1.2										7.0		
Buffalo	767	247	280	29.16	30.00	– .05	43.0	+ 3.7	64	8	48	22	26	38	26	39	35	76	1.43	–1.9	12	15,217	w.	76	sw.	29	3	6	21	8.1	T.	.....
Canton	448	10	61	29.48	29.96	.....	37.4	+ 3.5	58	18	44	13	26	31	26	.....	.....	.....	2.34	–1.1	15	7,540	w.	43	w.	29	5	7	18	7.2	3.8	T.
Oswego	335	76	91	29.62	30.00	– .05	41.6	+ 2.5	62	15	47	20	26	36	27	38	33	73	1.97	–1.4	17	8,981	s.	39	nw.	25	5	3	22	7.7	1.5	1.5
Rochester	523	97	113	29.44	30.02	– .03	42.4	+ 4.5	66	7	48	20	26	36	28	37	32	72	1.77	–1.0	16	6,865	sw.	36	sw.	29	6	3	21	7.5	0.4	0.3
Syracuse	597	97	113	29.38	30.03	– .03	41.8	+ 3.1	63	17	48	17	26	36	25	.....	.....	.....	1.18	–1.5	15	9,062	w.	49	s.	9	5	4	21	7.7	0.7	.....
Erie	714	130	166	29.24	30.02	– .04	43.7	+ 2.6	67	7	49	28	25	38	24	38	33	69	2.33	–1.3	12	11,880	sw.	60	w.	30	3	8	19	7.5	0.8	T.
Cleveland	762	190	201	29.21	30.05	– .02	43.2	+ 2.8	67	7	49	24	25	38	26	38	33	71	1.77	–1.0	12	9,767	sw.	52	w.	30	6	9	15	6.7	T.	.....
Sandusky	629	62	103	29.36	30.05	– .03	42.8	+ 2.0	67	7	49	22	25	36	27	.....	.....	.....	1.17	–1.6	9	10,400	sw.	54	sw.	28	7	7	16	6.6	T.	.....
Toledo	628	208	243	29.36	30.05	– .02	42.8	+ 3.1	65	7	49	22	25	36	24	38	33	74	1.46	–1.2	9	10,928	sw.	64	sw.	28	9	8	13	5.9	T.	.....
Fort Wayne	856	113	124	29.12	30.07	.....	42.0	+ 1.4	65	6	49	21	25	35	30	37	34	77	2.28	.....	11	7,035	sw.	48	sw.	28	9	8	13	5.7	T.	.....
Detroit	730	218	245	29.22	30.03	– .03	42.3	+ 3.7	62	7	48	23	25	37	17	38	34	77	2.12	–0.5	12	8,945	w.	60	sw.	28	8	6	16	6.3	T.	T.
Upper Lake region.							39.3	+ 5.0										80	2.81	+0.4										7.0		
Alpena	609	13	92	29.29	29.96	– .05	38.8	+ 5.1	60	15	44	17	30	34	19	36	33	82	3.20	+0.6	14	8,930	w.	37	se.	28	2	9	19	7.8	0.8	0.8
Escanaba	612	54	60	29.28	29.96	– .07	38.0	+ 6.3	58	8	44	12	30	33	29	35	32	82	2.58	+0.3	11	7,771	nw.	32	ne.	28	8	6	16	6.7	0.7	0.1
Grand Haven	632	54	92	29.30	30.00	– .04	41.6	+ 3.6	64	6	47	24	30	36	28	38	34	76	3.68	+1.2	12	10,681	w.	51	w.	28	5	7	18	7.1	0.3	T.
Grand Rapids	707	70	87	29.23	30.01	– .04	42.2	+ 4.1	63	6	48	23	30	36	26	38	34	78	2.63	+0.1	11	5,080	nw.	28	w.	28	4	6	20	7.8	0.3	0.3
Houghton	684	62	99	29.18	29.92	– .10	36.6	+ 5.1	57	8	42	12	30	31	28	.....	.....	.....	3.24	+0.4	14	7,884	e.	40	nw.	24	4	6	20	7.9	11.2	5.8
Lansing	878	11	62	29.05	30.01	.....	40.4	+ 3.6	63	17	47	20	26	33	25	36	33	83	3.22	+0.8	11	5,366	sw.	36	sw.	28	7	7	16	6.7	0.1	0.1
Ludington	637	60	66	29.27	29.98	.....	41.2	.....	59	6	46	22	30	36	23	38	34	78	2.83	.....	14	9,693	w.	40	s.	28	5	8	17	6.9	1.8	.....
Marquette	734	77	111	29.15	29.96	– .06	37.4	+ 5.5	59	8	43	14	30	32	24	34	32	82	5.29	+2.5	16	9,258	nw.	42	s.	11	2	9	19	7.5	22.6	9.3
Port Huron	638	70	120	29.29	30.00	– .05	41.0	+ 4.2	62	17	47	21	30	35	22	38	34	82	1.77	–0.9	10	8,977	sw.	45	nw.	30	7	11	12	6.2	0.1	0.1
Saginaw	641	48	82	29.29	30.00	.....	41.1	.....	61	6	48	19	30	35	27	36	33	80	3.05	+0.8	9	7,850	sw.	40	sw.	28	8	7	15	6.5	0.3	0.3
Sault Sainte Marie	614	11	61	29.24	29.95	– .06	37.7	+ 7.0	58	15	43	6	30	32	22	35	32	83	2.53	–0.4	17	7,585	nw.	35	w.	9	1	6	23	8.5	3.9	1.0
Chicago	823	140	310	29.14	30.04	– .03	43.5	+ 4.3	68	6	49	21	30	38	24	39	34	69	2.65	+0.2	9	9,578	w.	50	sw.	28	12	6	12	5.4	0.5	.....
Green Bay	617	109	144	29.29	29.97	– .07	38.8	+ 6.3	61	6	44	15	30	38	30	35	31	77	2.16	+0.2	8	9,573	s.	36	n.	28	8	3	19	7.1	T.	T.
Milwaukee	681	119	133	29.25	30.00	– .05	41.2	+ 5.1	65	6	47	20	24	35	26	37	34	79	1.37	–0.6	6	7,942	w.	40	e.	28	10	7	13	5.6	T.	.....
Duluth	1,133	11	47	28.71	29.96	– .08	33.6	+ 4.3	56	5	40	8	30	28	27	31	28	83	1.94	+0.4	8	10,287	nw.	53	w.	18	6	7	17	6.6	0.4	0.3
North Dakota.							30.0	+ 5.4										82	1.16	+0.4										5.6		
Moorhead	940	8	57	28.97	30.02	– .05	32.2	+ 7.8	65	5	40	8	23	25	27	30	28	91	1.27	+0.3	6	7,028	nw.	32	se.	5	11	6	13	5.6	2.0	0.1
Bismarck	1,674	8	57	28.22	30.06	– .01	31.4	+ 5.4	56	3	42	2	23	21	31	27	23	80	0.51	–0.2	3	6,755	nw.	38	nw.	17	15	5	10	4.3	3.5	.....
Devils Lake	1,482	11	44	28.37	29.99	– 0.7	27.1	+ 4.5	59	5	34	6	29	20	28	25	23	86	1.80	+1.1	9	7,702	nw.	34	nw.	8	8	5	17	6.9	8.9	0.6
Ellendale	1,475	10	56	28.42	30.02	.....	29.4	.....	65	5	38	3	9	20	39	27	25	87	2.16	.....	5	9,988	nw.	58	nw.	17	10	5	15	5.9	10.3	0
Grand Forks	835	12	89	.....	.....	.....	30.1	.....	65	5	37	10	29	23	30	.....	.....	.....	1.03	.....	7	.....	w.	38	nw.	20	8	5	17	.....	5.7	T.
Williston	1,872	41	48	27.98	30.02	– .04	29.2	+ 4.0	59	4	38	2	24	21	34	25	19	70	1.04	+0.4	4	5,509	sw.	32	w.	30	10	11	9	5.6	2.3	T.
Upper Mississippi Valley.							42.1	+ 4.3										76	2.25	0.0										5.6		
Minneapolis	918	10	208	28.96	29.96	.....	37.8	.....	64	14	44	14	23	31	28	.....	.....	.....	4.06	+2.9	10	9,293	nw.	37	nw.	18	6	10	14	6.8	0.5	T.
St. Paul	837	201	236	29.06	29.98	– .08	37.3	+ 6.3	62	14	44	15	23	30	28	.....	.....	.....	3.45	+2.2	11	9,803	nw.	42	se.	5	9	6	15	6.4	1.5	T.
La Crosse	714	11	48	29.20	29.99	– .08	40.0	+ 6.2	70	6	48	15	30	32	37	.....	.....	.....	1.37	–0.2	9	4,478	w.	19	sw.	8	10	4	16	6.3	6.0	4.2
Madison	974	70	78	28.95	30.02	– .04	39.4	+ 5.2	62	14	46	14	30	33	30	35	32	79	1.17	–0.6	7	7,967	s.	27	ne.	28	9	6	15	6.1	1.0	T.
Wausau	1,247	4	.....	28.60	29.96	.....	36.2	.....	61	6	43	7	30	30	35	.....	.....	.....	2.00	.....	9	.....	nw.	.....	.....	.....	8	4	18	6.7	7.4	7.0
Charles City	1,015	10	49	28.91	30.02	– 0.6	37.8	+ 4.8	69	6	46	12	30	30	32	34	32	84	1.80	+0.4	8	5,885	nw.	24	se.	5	9	7	14	5.9	7.0	4.0
Davenport	606	71	79	29.37	30.04	– .04	42.2	+ 4.7	66	6	49	17	24	35	26	38	34	79	1.89	+0.1	8	5,812	w.	26	nw.	18	15	2	13	5.0	T.	T.
Des Moines	861	84	97	29.11	30.03	– .05	41.6	+ 4.8	70	6	50	16	24	34	29	37	33	75	2.10	+0.6	11	5,968	s.	32	nw.	17	10	8	12	5.3	7.2	4.0
Dubuque	698	81	96	29.28	30.05	– .02	41.2	+ 5.2	67	6	48	16	24	34	30	36	32	74	1.10	–0.7	7	5,162	nw.	26	nw.	18	13	6	11	5.2	2.0	0.7
Keokuk	614	64	78	29.38	30.07	– .02	43.8	+ 4.4	75	6	51	20	24	36	30	38	34	75	2.91	+1.1	6	6,366	w.	32	w.	28	13	7	10	4.6	0.6	.....
Cairo	356	87	93	29.71	30.10	– .01	47.8	+ 0.9	71	6	55	29	30	40	26	42	36	68	1.34	–2.7	7	6,467	n.	48	sw.	28	13	3	14	5.0	.....	.....
Peoria	609	11	45	29.39	30.06	– .03	41.9	+ 4.4	72	6	50	18	24	34	29	37	34	82	3.18	+0.5	7	5,656	w.	35	sw.	28	14	4	12	5.0	T.	.....
Springfield, Ill.	644	10	91	29.37	30.06	– .04	43.2	+ 2.5	70	6	50	23	24	36	27	38	34	74	2.29	–3.7	8	6,505	w.	35	sw.	28	11	6	13	5.6	T.	.....
Hannibal	534	74	109	29.48	30.07	– .02	44.4	+ 3.9	76	6	52	22	26	37	29	.....	.....	.....	2.11	+0.2	9	6,790	sw.	33	sw.	28	14	5	11	5.1	T.	.....
St. Louis	567	265	303	29.46	30.08	– .02	46.2	+ 2.8	75	6	53	27	25	40	27	40	35	70	2.73	–0.2	9	9,686	nw.	52	sw.	28	11	6	13	5.3	T.	.....
Missouri Valley.							41.0	+4.3										77	2.44	+1.2										4.9		
Columbia, Mo.	781	11	84	29.23	30.08	– .01	44.9	+2.5	77	6	53	23	25	37	33	.....	.....	.....	2.47	+0.2	9	6,124	w.	30	sw.	28	12	7	11	5.2	T.	.....
Kansas City	963	161	181	29.02	30.08	– .01	45.6	+4.1	73	5	52	23	24	39	25	40	35	71	4.61	+2.8	8	8,737	s.	41	nw.	18	14	5	11	4.8	3.4	T.
St. Joseph	967	11	49	29.01	30.06	.....	43.7	.....	74	5	51	21	24	36	27	39	35	77	2.82	.....	6	6,834	s.	34	nw.	18	14	6	10	4.5	3.2	0.4
Springfield, Mo.	1,324	98	104	28.66	30.09	– .01	45.3	+0.9	73	6	52	25	30	38	26	40	36	78	3.90	+1.3	10	7,851	se.	44	nw.	17	15	6	9	4.3	0.4	.....
Iola	984	11	50	29.02	30.08	– .01	45.6	+2.6	74	4	54	23	30	37	35	.....	.....	.....	2.89	+1.5	6	5,530	s.	29	nw.	17	13	5	12	5.3	0.5	.....
Topeka	983	85	101	.....	.....	.....	44.0	+2.3	73	5	52	20	29	36	29	.....	.....	.....	3.51	+2.2	9	7,720	w.	40	nw.	17	14	2	14	4.8	4.6	1.5
Drexel	1,299	10	54	28.61	30.03	.....	39.4	.....	66	4	47	13	24	32	26	34	33	85	2.66	.....	10	8,830	nw.	38	sw.	14	15	5	10	4.6	3.5	0.8
Lincoln	1,189	11	84	28.75	30.05	– .03	41.6	+3.6	72	4	50	16	24	34	33	37	33	77	1.92	+1.1	9	6,817	s.	48	nw.	17	16	2	12	4.8	2.4	0.5
Omaha	1,105	115	122	28.84	30.05	– .03	41.6	+3.9	68	4	49	18	24	34	26	37	33	77	2.89	+1.8	9	6,608	nw.	37	nw.	17	13	5	12	5.0	4.2	1.8
Valentine	2,598	47	54	27.28	30.07	– .01	36.0	+2.3	69	13	48	3	24	24	45	29	24	72	0.20	–0.5	6	7,141	nw.	44	nw.	17	17	6	7	4.1	0.6	.....
Sioux City	1,135	94	164	28.79	30.03	– .05	39.0	+4.7	65	4	46	13	24	32	30	35	33	82	2.38	+1.4	10	8,912	nw.	49	nw.	17	11	6	13	5.5	3.5	.....
Huron	1,306	59	74	28.61	30.04	– .04	34.5	+7.1	68	5	44	5	23	25	31	31	28	81	1.74	+1.2	7	8,329	nw.	44	nw.	17	12	6	12	5.5	4.8	.....
Pierre	1,572	70	75	28.35	30.06	– .02	36.2	+4.6	69	4	47	0	24	25	39	30	26	74	0.45	0.0	6	6,269	nw.	42	nw.	17	17	5	8	3.9	3.6	.....
Yankton	1,233	49	57	28.68	30.03	– .05	38.0	+4.5	67	5	47	10	23	29	35	.....	.....	.....	2.38	+1.6	8	5,731	nw.	34	nw.	17	9	9	12	6.0	0.4	.....

TABLE I.—*Climatological data for Weather Bureau Stations, November, 1918*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level.	Elevation of instruments. Thermometer above ground.	Elevation of instruments. Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Maximum.	Temperature of the air. Date.	Temperature of the air. Mean maximum.	Temperature of the air. Minimum.	Temperature of the air. Date.	Temperature of the air. Mean minimum.	Temperature of the air. Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Days with .01 inch or more.	Wind. Total movement.	Wind. Prevailing direction.	Wind. Maximum velocity. Miles per hour.	Wind. Maximum velocity. Direction.	Wind. Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope.							31.8	−0.2										71	0.52	−0.2										4.9		
Billings	3,140	5	...	...	...	...	30.6	...	62	14	43	−16	24	18	41	...	...	...	1.44	...	6	...	...	...	...	...	11	12	7	...	12.9	T.
Havre	2,505	11	44	27.34	30.05	+.02	29.9	−0.7	59	14	41	−13	24	19	40	26	22	79	0.53	−0.2	4	5,488	sw.	48	sw.	30	8	9	13	5.8	2.4	...
Helena	4,110	87	114	25.80	30.10	.00	32.3	+1.4	62	3	41	1	23	24	31	26	19	63	0.15	−0.6	3	5,234	sw.	36	sw.	30	11	9	10	5.4	1.9	T.
Kalispell	2,962	11	34	26.96	30.08	+.01	32.8	+0.8	50	2	40	7	24	25	22	29	25	74	0.23	−1.7	3	3,388	nw.	24	sw.	30	7	8	15	6.6	0.2	0
Miles City	2,371	26	48	27.50	30.13	+.06	30.9	0.0	62	3	40	− 9	24	22	32	26	24	84	1.30	+0.7	7	3,664	se.	30	w.	30	15	10	5	3.8	5.2	T.
Rapid City	3,259	50	58	26.59	30.10	+.02	34.8	+1.2	72	4	46	−11	23	23	41	28	20	58	0.21	−0.2	3	6,258	w.	39	nw.	16	17	5	8	3.9	2.3	...
Cheyenne	6,088	84	101	23.96	30.09	+.02	30.9	−4.0	63	1	41	− 9	23	20	33	25	18	66	0.54	+0.1	5	9,193	w.	48	w.	8	17	8	5	4.1	8.9	0.3
Lander	5,372	60	68	24.64	30.18	+.08	26.3	−2.4	68	3	39	−15	25	14	40	20	14	69	0.93	+0.3	6	2,344	sw.	34	sw.	4	7	11	12	6.1	9.3	2.4
Sheridan	3,790	10	47	26.10	30.12	...	29.4	...	68	4	42	−16	24	17	40	24	19	73	0.58	...	6	3,836	nw.	38	nw.	30	14	5	11	4.8	5.5	0.3
Yellowstone Park	6,200	11	48	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
North Platte	2,821	11	51	27.10	30.11	+.03	36.8	+1.7	72	11	50	6	23	24	45	29	23	69	0.29	−0.1	5	5,144	nw.	37	nw.	17	17	4	9	4.0	1.5	...
Middle Slope.							41.8	0.0										72	1.72	+0.8										4.3		
Denver	5,292	106	113	24.71	30.08	+.02	36.6	−2.6	75	3	47	4	24	26	37	29	23	64	0.88	+0.4	7	4,964	s.	31	sw.	4	18	8	4	3.5	14.2	1.0
Pueblo	4,685	80	86	25.28	30.07	+.02	36.3	−3.0	75	2	50	− 2	26	23	43	29	21	61	0.66	+0.3	6	4,391	nw.	37	nw.	16	15	9	6	3.6	7.8	1.2
Concordia	1,392	50	58	28.58	30.08	.00	42.9	+3.0	75	6	51	19	24	35	32	38	34	78	1.24	+0.3	8	6,759	s.	44	nw.	17	16	0	14	4.9	3.4	0.3
Dodge City	2,509	11	51	27.42	30.08	.00	41.7	+1.2	71	11	52	16	26	32	36	35	30	72	0.37	−0.2	6	7,377	s.	40	nw.	17	14	5	11	4.5	3.4	T.
Wichita	1,358	139	158	28.61	30.07	−.01	44.8	+1.0	71	4	52	23	24	38	26	40	37	77	3.62	+2.4	6	9,312	s.	48	nw.	17	15	4	11	4.4	2.1	...
Altus	1,410	5	...	...	...	...	49.4	...	78	16	59	24	23	40	35	...	...	...	1.32	...	8	...	se.	...	...	...	17	1	12	...	5.5	...
Muskogee	652	4	...	...	...	...	49.5	...	75	3	59	26	29	40	34	...	...	...	3.19	...	11	...	n.	...	...	...	13	5	12	...	0.3	...
Oklahoma	1,214	10	47	28.79	30.10	+.02	48.2	+0.3	74	6	56	27	30	40	29	42	39	78	3.53	+1.3	7	9,902	s.	45	nw.	17	14	5	11	4.8	2.3	...
Southern Slope.							48.5	−2.5										68	1.44	+0.9										4.7		
Abilene	1,738	10	52	28.25	30.08	+.01	50.6	−2.0	81	6	59	23	24	42	30	44	38	70	1.98	+0.7	6	7,848	s.	39	w.	16	11	6	13	5.4	8.2	T.
Amarillo	3,676	10	49	26.28	30.07	.00	42.6	−1.2	78	2	53	16	30	32	36	36	31	73	1.16	0.0	8	7,863	s.	33	n.	16	15	9	6	3.7	10.8	2.0
Del Rio	944	64	71	29.06	30.06	+.01	56.8	−2.5	79	16	64	31	28	49	32	...	...	...	0.92	−0.3	10	6,685	se.	34	nw.	16	9	11	10	5.6	...	...
Roswell	3,566	75	85	26.38	30.04	+.01	43.9	−4.2	79	2	56	9	30	32	40	36	27	60	1.70	+0.5	7	5,794	s.	42	nw.	16	17	6	7	4.0	12.8	1.8
Southern Plateau.							46.5	−2.4										54	0.73	+0.2										3.2		
El Paso	3,762	110	133	26.20	30.00	.00	49.1	−1.8	80	5	59	23	26	39	35	40	31	58	1.04	+0.4	9	7,894	w.	48	ne.	25	14	7	9	4.3	2.4	...
Santa Fe	7,013	57	66	23.21	30.05	+.03	35.0	−3.2	65	3	44	9	30	26	29	28	21	66	0.63	−0.2	10	4,990	sw.	32	nw.	8	14	9	7	4.2	2.8	T.
Flagstaff	6,908	8	57	23.30	29.98	−.04	31.3	−3.3	70	1	44	− 4	27	18	45	26	...	...	1.35	...	10	...	w.	44	sw.	4	18	5	7	...	9.3	3.0
Phoenix	1,108	76	81	28.79	29.96	−.02	57.2	−1.5	89	3	71	31	30	44	46	46	38	59	1.92	+1.0	5	3,282	e.	19	n.	6	19	8	3	2.7	...	...
Yuma	141	9	54	29.82	29.96	−.02	60.4	−1.5	90	1	74	35	30	47	39	48	36	47	0.07	−0.2	2	4,162	n.	33	nw.	25	26	3	1	1.2	...	...
Independence	3,910	11	42	26.00	30.07	+.02	46.2	−3.0	75	3	59	23	30	34	35	35	20	40	T.	−0.3	0	4,710	nw.	32	nw.	28	16	9	5	3.4	...	...
Needles	488	4	...	29.46	29.98	...	56.6	...	90	3	71	31	30	43	45	...	...	...	0.19	...	2	...	...	...	...	...	20	1	9	...	...	...
Middle Plateau.							36.4	−3.1										61	0.68	−0.2										4.6		
Reno	4,532	74	81	25.48	30.09	− 0.2	39.1	− 1.9	70	2	51	13	28	27	39	32	25	60	0.37	−0.7	3	3,703	w.	41	se.	3	14	8	8	4.7	T.	...
Tonopah	6,090	12	20	24.05	30.06	...	36.6	...	66	1	44	7	28	29	22	31	24	47	0.13	−0.8	3	6,823	se.	36	nw.	24	16	7	7	3.9	1.4	T.
Winnemucca	4,344	18	56	25.66	30.14	.00	34.2	−3.3	69	2	48	− 6	28	44	20	28	23	70	0.77	0.0	7	4,493	sw.	42	sw.	3	12	6	12	5.1	9.3	2.6
Modena	5,479	10	43	24.61	30.05	−.03	33.9	−5.1	70	2	48	8	27	20	45	26	18	60	0.30	−0.3	7	6,406	w.	48	s.	4	14	6	10	4.4	0.9	...
Salt Lake City	4,360	163	203	25.63	30.07	−.05	38.8	−1.7	70	3	47	15	28	31	27	33	26	64	1.77	+0.4	9	4,445	nw.	45	nw.	15	9	12	9	5.2	10.6	T.
Grand Junction	4,602	82	96	25.41	30.05	−.03	36.3	−3.6	74	3	47	4	27	26	35	30	23	66	0.75	+0.2	7	3,275	se.	45	s.	4	14	9	7	4.2	6.8	1.5
Northern Plateau.							38.7	+0.1										72	0.67	−0.9										6.2		
Baker	3,471	48	53	26.48	30.13	−.03	35.0	+0.1	55	1	44	5	26	26	28	31	27	74	0.56	−0.6	7	4,864	se.	23	s.	3	10	10	10	5.0	5.0	1.0
Boise	2,739	78	86	27.24	30.14	−.03	39.6	0.0	63	2	49	20	28	30	30	35	28	66	0.24	−0.6	4	3,312	se.	27	w.	27	11	9	10	5.1	T.	...
Lewiston	757	40	48	29.30	30.13	+.01	41.4	+0.5	58	1	50	19	24	33	26	...	...	...	0.34	−1.0	8	1,649	e.	19	nw.	14	6	5	19	7.1	0.8	...
Pocatello	4,477	60	68	25.49	30.10	−.04	34.8	−1.5	64	3	44	8	28	26	31	30	24	67	0.44	−1.1	5	6,303	se.	40	s.	3	8	11	11	5.6	1.3	T.
Spokane	1,929	101	110	28.01	30.10	.00	38.5	+1.2	55	13	45	17	25	32	25	35	32	77	1.43	−0.9	10	4,140	ne.	33	sw.	15	4	6	20	7.3	2.0	T.
Walla Walla	991	57	65	29.02	30.11	−.02	42.7	+0.2	62	10	50	20	26	36	26	39	35	76	1.02	−1.1	7	3,247	s.	33	sw.	14	5	8	17	7.1	1.0	...
North Pacific Coast Region.							46.6	+1.0										85	4.91	−2.0										7.8		
North Head	211	11	56	29.79	30.02	−.03	48.3	+0.6	59	18	52	38	27	45	11	47	45	89	6.62	+0.3	22	12,133	e.	88	se.	10	3	11	16	7.2	...	...
North Yakima	1,071	4	...	...	...	...	99.4	...	61	10	51	18	23	28	32	...	...	...	0.51	...	3	...	nw.	...	...	...	11	5	14	...	T.	...
Port Angeles	29	8	53	29.99	30.02	...	43.4	...	56	1	50	30	23	37	23	...	...	...	3.25	−1.2	18	3,987	s.	30	sw.	26	3	4	23	8.2	...	...
Seattle	125	215	250	29.93	30.06	+.02	45.8	+1.3	60	17	50	32	27	41	16	44	40	82	3.81	−2.0	18	6,415	se.	48	s.	13	1	4	25	8.9	...	...
Tacoma	213	113	120	29.82	30.05	+.01	45.5	+1.4	58	17	51	30	27	40	19	44	41	85	3.76	−4.8	16	4,071	sw.	28	sw.	26	1	8	21	7.9	...	...
Tatoosh Island	86	7	57	29.87	29.97	.00	47.7	+1.8	55	17	51	38	26	44	13	45	42	81	7.88	−4.2	22	13,547	e.	73	s.	13	3	9	18	7.6	T.	...
Medford	1,425	4	...	...	...	...	41.6	...	63	1	50	28	8	33	28	...	...	...	2.29	...	11	...	se.	...	...	...	4	8	18	...	1.0	...
Portland, Oreg.	153	68	106	29.91	30.07	−.03	46.6	+1.0	60	12	52	34	27	42	24	44	42	87	4.30	−2.2	18	4,293	se.	25	sw.	10	1	8	21	7.9	...	...
Roseburg	510	9	57	29.55	30.11	−.01	45.8	+0.2	60	2	52	31	29	39	22	43	41	86	4.73	+0.4	13	1,820	s.	22	sw.	15	1	16	13	6.9	...	...
Middle Pacific Coast Region.							51.6	−1.5										75	4.05	+0.9										4.6		
Eureka	62	73	89	30.03	30.10	−.01	50.0	−1.0	65	18	56	33	28	44	23	47	45	84	4.74	−0.9	10	4,338	se.	41	n.	27	10	6	14	5.9	...	...
Mount Tamalpais	2,375	11	18	27.58	30.07	−.02	48.3	−2.3	70	1	53	36	4	44	19	43	37	70	5.18	+1.5	12	11,783	nw.	60	se.	3	12	9	9	4.6	...	...
Point Reyes Light	490	7	18	29.52	30.03	...	53.6	+0.6	63	9	58	46	5	50	13	...	...	...	3.15	...	7	11,616	nw.	73	se.	17	12	8	10	5.1	...	...
Red Bluff	332	50	56	29.72	30.08	−.03	51.0	−2.4	76	1	60	34	26	42	28	46	40	70	4.70	+1.5	7	3,779	nw.	31	n.	27	15	5	10	4.8	...	...
Sacramento	69	106	117	30.00	30.07	−.02	50.6	−2.8	79	1	60	34	28	42	32	47	43	77	1.84	−0.3	9	5,196	se.	37	nw.	27	18	5	7	3.7	...	...
San Francisco	155	209	213	29.90	30.07	−.02	55.6	+0.1	72	1	61	45	29	50	18	50	46	73	5.60	+3.1	9	4,913	ne.	42	ne.	27	18	7	5	3.2	...	...
San Jose	141	12	110	29.93	30.08	...	51.8	−2.6	73	1	62	32	29	41	31	...	...	...	2.24	+0.4	10	3,983	se.	35	se.	17	14	6	10	4.8	...	...
South Pacific Coast Region.							57.6	+0.5										67	2.39	+1.2										3.4		
Fresno	327	89	98	29.71	30.07	+.01	52.8	−1.8	81	1	62	31	28	43	30	47	42	72	1.81	+0.8	6	3,569	nw.	24	nw.	24	15	8	7	4.1	...	...
Los Angeles	338	159	191	29.65	30.01	−.01	60.8	+2.4	86	10	69	45	29	52	28	52	44	60	1.85	+0.4	5	4,994	ne.	38	nw.	24	17	6	7	3.1	...	...
San Diego	87	62	70	29.91	30.00	−.02	59.8	+0.8	82	1	68	42	29	52	22	53	47	67	1.91	+1.1	7	4,186	nw.	32	nw.	24	19	5	6	3.0	...	...
San Luis Obispo	201	32	40	29.83	30.05	−.01	56.8	+0.5	81	1	68	36	30	46	37	49	43	68	4.00	+2.3	10	2,894	n.	22	sw.	17	16	8	6	3.6	...	...
West Indies.																																
San Juan, P. R.	82	8	54	29.85	29.94	...	77.4	...	88	19	82	70	7	72	16	...	...	...	4.24	−2.7	17	6,109	se.	33	ne.	17	13	10	7	4.7	...	...
Panama Canal.																																
Balboa Heights	118	7	97	29.71	29.84	.00	80.2	+1.2	92	3	87	70	11	73	20	75	74	90	9.61	−0.7	16	4,533	nw.	28	nw.	15	2	14	14	6.8	...	...
Colon	36	30	97	29.81	29.84	−.01	79.8	+1.1	86	4	84	72	20	76	10	76	74	84	14.23	−7.1	24	6,783	n.	27	nw.	15	4	7	19	7.3	...	...
Alaska.																																
Juneau	80	11	49	...	...	...	37.5	...	51	21	42	23	18	33	19	35	33	84	15.01	...	25	3,985	se.	21	se.	26	2	3	25	9.0	6.1	...

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes or 0.80 in 1 hour, during November, 1918, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	7	6:25 a. m.	7:30 a. m.	0.77	6:40 a. m.	7:07 a. m.	0.10	0.09	0.15	0.23	0.34	0.62	0.66								
Albany, N. Y	18			1.68														0.51			
Alpena, Mich	7			0.76														0.38			
Amarillo, Tex	24-25			0.92														*			
Anniston, Ala	16			1.34														0.39			
Asheville, N. C	28			0.61														0.31			
Atlanta, Ga	28			1.15														0.37			
Atlantic City, N. J	28			0.22														0.08			
Augusta, Ga	28			1.71														0.56			
Baker, Oreg	24-25			0.28														*			
Baltimore, Md	18			0.62														0.50			
Bentonville, Ark	7			0.57														0.25			
Binghamton, N. Y	17			0.53														0.44			
Birmingham, Ala	16	5:00 p. m.	6:10 p. m.	0.92	5:44 p. m.	5:55 p. m.	0.07	0.34	0.80	0.83											
Bismarck, N. Dak	2			0.22														*			
Block Island, R. I	28-29			0.35														0.18			
Boise, Idaho	15			0.15														0.10			
Boston, Mass	18			0.21														0.14			
Buffalo, N. Y	17			0.45														0.23			
Burlington, Vt	18			2.29														0.73			
Cairo, Ill	27			0.70														0.33			
Canton, N. Y	17-18			0.74														*			
Charles City, Iowa	27-28			0.63														*			
Charleston, S. C	28			0.55														0.26			
Charlotte, N. C	16-17	D. N. p. m.	7:37 a. m.	0.89	11:25 p. m.	11:43 p. m.	0.21	0.26	0.36	0.49	0.54										
Chattanooga, Tenn	28			1.18														0.42			
Cheyenne, Wyo	5-6			0.29														*			
Chicago, Ill	7			0.85														0.28			
Cincinnati, Ohio	28			0.83														0.50			
Cleveland, Ohio	1			0.57														*			
Columbia, Mo	7			0.86														0.39			
Columbia, S. C	28			1.22														0.25			
Columbus, Ohio	28			0.42														0.28			
Concord, N. H	18			1.00														0.38			
Concordia, Kans	7			0.49														0.48			
Corpus Christi, Tex	22			1.00														0.18			
Dallas, Tex	7-8	7:12 a. m.	1:41 p. m.	4.45	3:51 p. m.	3:06 p. m.	0.11	0.25	0.49	0.71											
	14-15	2:04 p. m.	10:19 a. m.	1.64	9:39 a. m.	9:49 a. m.	1.03	0.24	0.51												
Davenport, Iowa	27-28			1.17														0.28			
Dayton, Ohio	28			0.68														0.37			
Del Rio, Tex	25			0.30														0.08			
Denver, Colo	5-6			0.38														*			
Des Moines, Iowa	27-28			1.29														*			
Detroit, Mich	17			0.75														0.24			
Devils Lake, N. Dak	5			0.39														0.37			
Dodge City, Kans	7			0.11														*			
Drexel, Nebr	7			0.51														0.31			
Dubuque, Iowa	27-28			0.81														*			
Duluth, Minn	7-8			1.09														*			
Eastport, Me	17-18			0.96														*			
Elkins, W. Va	17			0.46														0.35			
Ellendale, N. Dak	7			0.89														*			
El Paso, Tex	24			0.23														0.19			
Erie, Pa	17			0.40														0.23			
Escanaba, Mich	17			0.44														0.18			
Eureka, Cal	3			1.45														0.32			
Evansville, Ind	27-28			0.50														0.28			
Flagstaff, Ariz	23-24			0.67														*			
Fort Smith, Ark	8			0.66														0.28			
Fort Wayne, Ind	17			0.37														0.25			
Fort Worth, Tex	6	6:20 p. m.	7:34 a. m.	2.24	8:28 p. m.	9:08 p. m.	0.14	0.14	0.22	0.34	0.44	0.50	0.57	0.61	0.70						
	7-8	9:15 a. m.	5:44 a. m.	3.79	1:23 p. m.	1:57 p. m.	0.48	0.10	0.21	0.39	0.52	0.60	0.66	0.73							
Fresno, Cal	23			0.62														0.18			
Galveston, Tex	15	D. N. a. m.	7:50 a. m.	1.47	5:30 a. m.	6:09 a. m.	0.37	0.11	0.20	0.28	0.39	0.48	0.54	0.63	0.69						
	21	D. N. a. m.	D. N. a. m.	1.12	3:08 a. m.	3:46 a. m.	0.01	0.06	0.19	0.40	0.55	0.70	0.82	1.03	1.09						
Grand Haven, Mich	17			0.48														0.29			
Grand Junction, Colo	22			0.25														*			
Grand Rapids, Mich	3			0.57														0.20			
Green Bay, Wis	3			1.01														0.27			
Greenville, S. C	28			1.84														0.57			
Hannibal, Mo	6			0.39														0.21			
Harrisburg, Pa	17-18			0.94														0.44			
Hartford, Conn	17			1.22														0.38			
Hatteras, N. C	18			1.15														*			
Havre, Mont	30			0.29														*			
Helena, Mont	4-5			0.11														*			
Houghton, Mich	18			0.72														*			
Houston, Tex	16	D. N. a. m.	5:37 a. m.	0.82	4:54 a. m.	5:11 a. m.	0.04	0.11	0.35	0.72	0.77										
	21	12:08 a. m.	D. N. a. m.	0.84	12:20 a. m.	12:48 a. m.	0.01	0.07	0.15	0.21	0.36	0.61	0.70								
Huron, S. Dak	16-17			0.81														*			
Independence, Cal	3			T														T			
Indianapolis, Ind	28			0.52														0.25			
Iola, Kans	7			1.74														0.29			
Jacksonville, Fla	26			0.97														0.37			
Kalispell, Mont	4			0.17														0.05			
Kansas City, Mo	7			2.74														0.67			
Keokuk, Iowa	16	4:30 p. m.	8:15 p. m.	1.36	6:15 p. m.	6:55 p. m.	0.02	0.05	0.12	0.27	0.28	0.42	0.48	0.68	0.79						
Key West, Fla	27			0.28														0.15			
Knoxville, Tenn	28			1.09														0.33			
La Crosse, Wis	27-28			0.94														*			
Lander, Wyo	21-22			0.60														*			
Lansing, Mich	8			1.34														0.20			
Lewiston, Idaho	14			0.15														0.08			
Lexington, Ky	17			1.11														0.41			
Lincoln, Nebr	7			0.45														0.31			
Little Rock, Ark	8			1.16														0.51			
Los Angeles, Cal	18			0.86														0.37			
Louisville, Ky	28			0.66														0.29			
Ludington, Mich	3			0.53														0.19			

* Self-register not in use.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes or 0.80 in 1 hour, during November, 1918, at all stations furnished with self-registering gages*—Continued.

Stations.*	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Lynchburg, Va.	17			0.68														0.27			
Macon, Ga.	27			0.89														0.39			
Madison, Wis.	28			0.76														0.16			
Marquette, Mich.	28			1.95														*			
Memphis, Tenn.	27			1.05														0.62			
Meridian, Miss.	17			0.58														0.46			
Miami, Fla.	18			0.30														0.30			
Milwaukee, Wis.	16			0.62														0.25			
Minneapolis, Minn.	16-17			1.60														0.34			
Mobile, Ala.	15	7:05 p.m.	D.N.a.m.	1.62	10:45 p.m.	11:04 p.m.	0.27	0.25	0.58	0.81	0.89										
	27	11:10 a.m.	7:30 p.m.	1.91	2:08 p.m.	3:08 p.m.	0.12	0.05	0.10	0.19	0.29	0.49	0.66	0.73	0.77	0.81	0.86	0.99			
Modena, Utah	22-23			0.16														*			
Montgomery, Ala.	27-28	11:45 a.m.	D.N.a.m.	2.45	2:57 a.m.	3:44 a.m.	1.32	0.10	0.20	0.30	0.36	0.48	0.55	0.72	0.96	1.05	1.10				
Moorehead, Minn.	16-17			0.72														*			
Mount Tamalpais, Cal.	18			1.89														0.39			
Nantucket, Mass.	17			0.38														0.24			
Nashville, Tenn.	17			0.41														0.29			
New Haven, Conn.	17			1.55														0.43			
New Orleans, La.	17	D.N.a.m.	D.N.a.m.	0.59	1:02 a.m.	1:27 a.m.	0.01	0.19	0.25	0.29	0.36	0.51									
New York, N. Y.	17			1.18														0.39			
Norfolk, Va.	18			0.38														0.19			
Northfield, Vt.	18			1.32														0.47			
North Head, Wash.	2			0.89														0.20			
North Platte, Nebr.	7			0.20														*			
Oklahoma, Okla.	6	1:14 p.m.	10:45 p.m.	2.09	7:26 p.m.	8:13 p.m.	0.41	0.29	0.37	0.42	0.52	0.62	0.76	0.86	1.01	1.31	1.36				
Omaha, Nebr.	7			0.84														0.44			
Oswego, N. Y.	17-18			0.67														*			
Palestine, Tex.	20	2:45 p.m.	8:50 p.m.	1.12	7:55 p.m.	8:13 p.m.	0.36	0.13	0.33	0.57	0.71										
Parkersburg, W. Va.	17			0.64														0.26			
Pensacola, Fla.	25-26	9:55 p.m.	4:50 a.m.	1.46	10:39 p.m.	11:04 p.m.	0.14	0.07	0.10	0.18	0.37	0.50	0.53								
Peoria, Ill.	7			1.95														0.37			
Philadelphia, Pa.	17-18			1.16														0.30			
Phoenix, Ariz.	14	8:19 a.m.	10:05 a.m.	0.70	8:25 a.m.	8:52 a.m.	0.01	0.07	0.18	0.32	0.43	0.48	0.54								
Pierre, S. Dak.	6			0.20														*			
Pittsburgh, Pa.	17			0.64														0.32			
Pocatello, Idaho	15			0.24														0.20			
Point Reyes Light, Cal.	3	6:10 a.m.	9:20 a.m.	0.82	8:11 a.m.	8:27 a.m.	0.25	0.12	0.36	0.47	0.51										
Port Angeles, Wash.	10			0.63														0.16			
Port Huron, Mich.	17			0.53														0.15			
Portland, Me.	17			1.08														0.24			
Portland, Oreg.	14			0.74														0.29			
Providence, R. I.	17			0.96														0.29			
Pueblo, Colo.	6-7			0.34														*			
Raleigh, N. C.	28			1.46														0.54			
Rapid City, S. Dak.	21-22			0.14														*			
Reading, Pa.	18			0.86														0.46			
Red Bluff, Cal.	3	D. N. A. M.	4:30 p. m.	1.31	9:08 a. m.	9:53 a. m.	0.18	0.05	0.22	0.32	0.37	0.42	0.52	0.60	0.66	0.72					
Reno, Nev.	15			0.18														*			
Richmond, Va.	18			0.48														0.46			
Rochester, N. Y.	17			0.52														0.18			
Roseburg, Oreg.	14			0.95														0.39			
Roswell, N. Mex.	25-26			0.65														*			
Sacramento, Cal.	23			0.85														0.21			
Saginaw, Mich.	17			0.73														0.53			
St. Joseph, Mo.	7			1.57														0.44			
St. Louis, Mo.	16			0.56														0.38			
St. Paul, Minn.	5-6			1.92														*			
Salt Lake City, Utah	15			0.39														*			
San Antonio, Tex.	14			0.98														0.62			
San Diego, Cal.	13			0.79														0.66			
Sandusky, Ohio	17-18			0.45														0.13			
Sandy Hook, N. J.	17			0.65														0.28			
San Francisco, Cal.	4	9:18 p. m.	10:35 p. m.	0.95	9:37 p. m.	10:07 p. m.	0.04	0.09	0.35	0.59	0.70	0.75	0.81								
San Jose, Cal.	23			0.71														0.24			
San Luis Obispo, Cal.	17			1.03														0.43			
Santa Fe, N. Mex.	14-15			0.23														*			
Sault Ste. Marie, Mich.	6-7			0.57														*			
Savannah, Ga.	26			1.72														0.53			
Scranto, Pa.	18			0.65														0.39			
Seattle, Wash.	12			0.48														0.13			
Sheridan, Wyo.	4-5			0.28														*			
Shreveport, La.	20			1.18														0.66			
Sioux City, Iowa	15-16			0.95														*			
Spokane, Wash.	9-10			0.40														*			
Springfield, Ill.	28			0.53														0.17			
Springfield, Mo.	7			1.62														0.34			
Syracuse, N. Y.	17-18			0.31														*			
Tacoma, Wash.	13			0.41														0.21			
Tampa, Fla.	26			2.42														0.56			
Tatoosh Island, Wash.	26			0.91														0.43			
Taylor, Tex.	8	9:25 p.m.	1:20 p.m.	1.67	7:33 a.m.	7:41 a.m.	0.03	0.41	0.55												
Terre Haute, Ind.	28			0.61														0.34			
Thomasville, Ga.	6			1.02														0.47			
Toledo, Ohio	28			0.28														0.13			
Tonopah, Nev.	27			0.08														*			
Topeka, Kans.	7			1.43														0.74			
Trenton, N. J.	17			0.95														0.36			
Valentine, Nebr.	6			0.09														*			
Vicksburg, Miss.	16	9:43 a.m.	12:50 p.m.	1.58	11:23 a.m.	12:05 p.m.	0.12	0.26	0.50	0.72	0.85	0.99	1.06	1.16	1.28	1.33					
Walla Walla, Wash.	3			0.33														0.16			
Washington, D. C.	18			0.76														0.46			
Wausau, Wis.	28			0.64														*			
Wichita, Kans.	1	3:05 p.m.	5:55 p.m.	0.95	4:52 p.m.	5:12 p.m.	0.14	0.30	0.56	0.69	0.76										
	6	6:05 a.m.	10:45 a.m.	1.89	8:09 a.m.	8:54 a.m.	0.44	0.10	0.21	0.28	0.35	0.38	0.42	0.54	0.59	0.66					
Williston, N. Dak.	5-6			0.85														*			
Wilmington, N. C.	28	12:40 p.m.	5:55 p.m.	1.18	2:00 p.m.	2:24 p.m.	0.33	0.17	0.35	0.50	0.55	0.64									
Winnemucca, Nev.	23			0.52														*			
Wytheville, Va.	28			0.57														0.15			
Yankton, S. Dak.	5			0.84														0.59			
Yellowstone Park, Wyo.																					

* Self-register not in use.

TABLE III.—*Data furnished by the Canadian Meteorological Service, November, 1918.*

Stations.	Altitude above M. S. L.[1] Jan. 1, 1916.	Pressure.			Temperature.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.61	29.75	−0.19	35.0	− 1.5	40.8	29.2	66	14	6.17	+0.60	4.0
Sydney, C. B. I.	48	29.85	29.89	− .06	38.5	+ 1.4	44.1	32.8	63	18	3.57	−1.87	1.5
Halifax, N. S.	88	29.83	29.94	− .07	38.1	+ 0.8	45.2	31.0	63	13	5.78	+0.12	4.1
Yarmouth, N. S.	65	29.87	29.94	− .08	39.8	− 0.1	46.0	33.7	57	19	6.92	+2.36	1.0
Charlottetown, P. E. I.	38	29.86	29.90	− .06	36.6	+ 1.1	41.1	32.2	60	14	3.53	−0.44	11.3
Chatham, N. B.	28	29.93	29.95	− .02	33.9	+ 2.9	39.9	27.9	60	11	2.93	−0.62	10.6
Father Point, Que.	20	29.88	29.90	− .06	30.5	+ 1.6	35.8	25.2	49	10	1.42	−1.69	5.4
Quebec, Que.	296	29.64	29.98	− .04	32.4	+ 3.4	37.6	27.2	52	10	2.88	−0.88	10.5
Montreal, Que.	187	29.76	29.98	− .05	34.8	+ 3.0	39.7	29.8	49	13	4.35	+0.61	3.2
Stonecliffe, Ont.	489	29.33	29.96	− .05	35.1	+ 6.0	42.8	27.4	56	6	2.59	+0.01	2.6
Ottawa, Ont.	236	29.73	30.00	− .02	35.6	+ 3.9	42.7	28.6	54	12	2.66	+0.12	8.8
Kingston, Ont.	285	29.68	30.00	− .04	40.6	+ 5.6	47.3	34.0	57	13	2.24	−1.00	0.9
Toronto, Ont.	379	29.58	30.00	− .04	42.0	+ 6.4	48.4	35.5	66	18	1.34	−1.80	1.9
White River, Ont.	1,244	28.55	29.91	− .07	29.9	+ 9.4	37.2	22.5	52	− 6	2.69	+0.84	5.7
Port Stanley, Ont.	592	29.37	30.03	− .02	41.3	+ 4.5	47.8	34.8	59	18	1.44	−1.93	T.
Southampton, Ont.	656	29.24	....	....	40.8	+ 5.8	46.2	35.4	59	16	4.71	+1.01	6.0
Parry Sound, Ont.	688	29.25	29.95	− .06	38.0	+ 5.9	44.9	31.1	58	10	4.60	+0.23	6.0
Port Arthur, Ont.	644	29.21	29.93	− .07	34.0	+10.0	41.0	27.0	58	5	1.68	+0.35	0.2
Winnipeg, Man.	760	29.09	29.95	− .09	30.4	+12.4	36.6	24.3	52	2	3.03	+1.95	5.8
Minnedosa, Man.	1,690	28.10	29.97	− .07	26.3	+ 9.0	34.2	18.4	49	− 1	0.92	−0.08	6.4
Qu'Appelle, Sask.	2,115	27.65	29.94	− .06	28.3	+ 9.5	38.7	17.9	58	2	0.30	−0.59	3.0
Medicine Hat, Alberta.	2,144	27.60	29.92	− .08	32.9	+ 5.5	44.7	21.2	61	− 4	0.33	−0.59	2.1
Swift Current, Sask.	2,392	27.31	29.94	− .08	29.0	+ 5.8	39.5	18.4	58	− 2	0.69	0.00	6.9
Calgary, Alberta.	3,428	26.32	29.90	− .08	35.0	+ 9.2	47.8	22.3	69	8	0.10	−0.78	1.0
Banff, Alberta.	4,521	25.33	30.04	+ .08	26.5	+ 0.7	34.6	18.4	43	− 2	0.73	−1.54	7.1
Edmonton, Alberta.	2,150	27.54	29.86	− .11	29.7	+ 6.8	38.9	20.5	56	− 3	0.31	−0.27	2.9
Prince Albert, Sask.	1,450	28.34	29.93	− .10	27.5	+12.1	37.2	17.9	56	0	0.48	−0.35	3.1
Battleford, Sask.	1,592	28.15	29.92	− .10	28.8	+12.5	40.2	17.3	58	0	0.12	−0.46	1.2
Kamloops, B. C.	1,262	28.78	30.02	+ .06	37.7	+ 4.3	43.3	32.1	56	14	0.62	−0.84	0.2
Victoria, B. C.	230	29.74	30.00	+ .01	45.4	+ 2.2	49.3	41.5	54	34	3.28	−3.69	....
Barkerville, B. C.	4,180	25.56	29.93	+ .03	26,6	+ 3.0	32.9	20.2	38	7	4.42	+1.13	44.2
Hamilton, Bermuda.	151	29.84	30.00	− .05	69.0	+ 0.3	73.9	64.1	79	58	11.44	+7.06	....

[1] See description of Table III in the REVIEW for January, p. 48.

Chart I. Hydrographs of Several Principal Rivers, November, 1918.

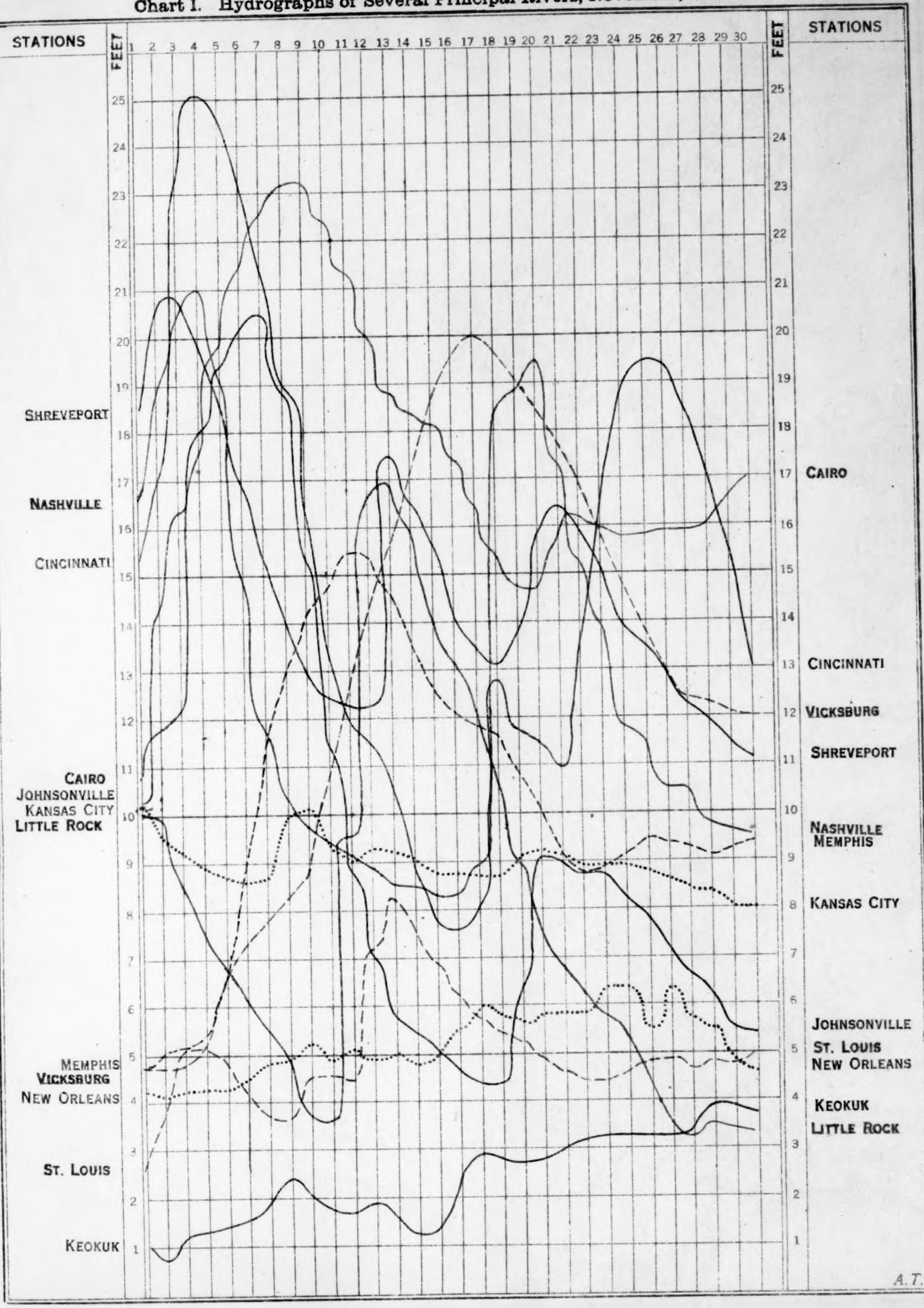

Chart II. Tracks of Centers of High Areas, November, 1918.

(Plotted by Charles A. Donnel.)

Chart III. Tracks of Centers of Low Areas, November, 1918.

Chart III. Tracks of Centers of Low Areas, November, 1918.
(Plotted by Charles A. Donnel.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, November, 1918.

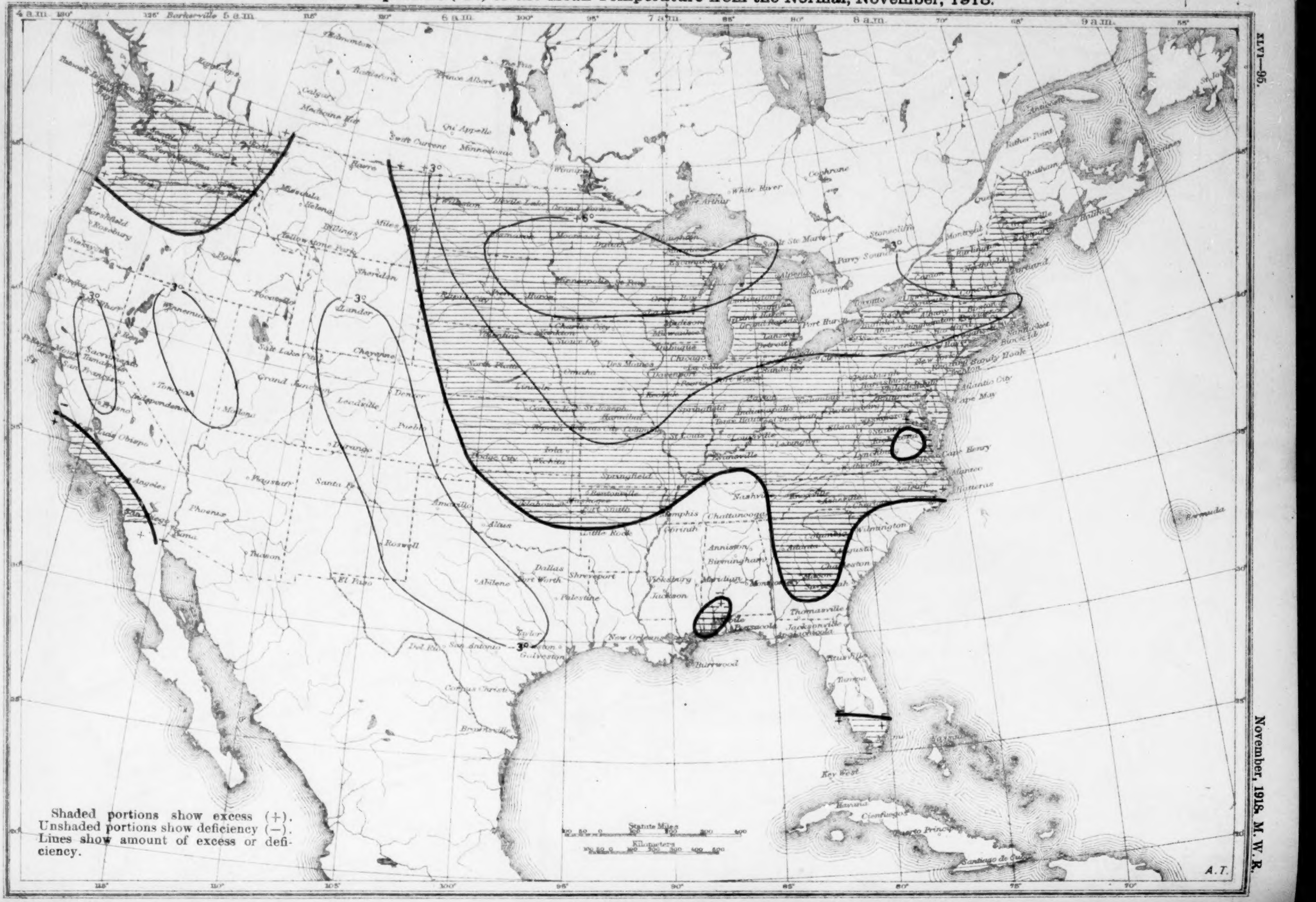

Chart V. Total Precipitation, Inches, November, 1918.

Chart V. Total Precipitation, Inches, November, 1918.

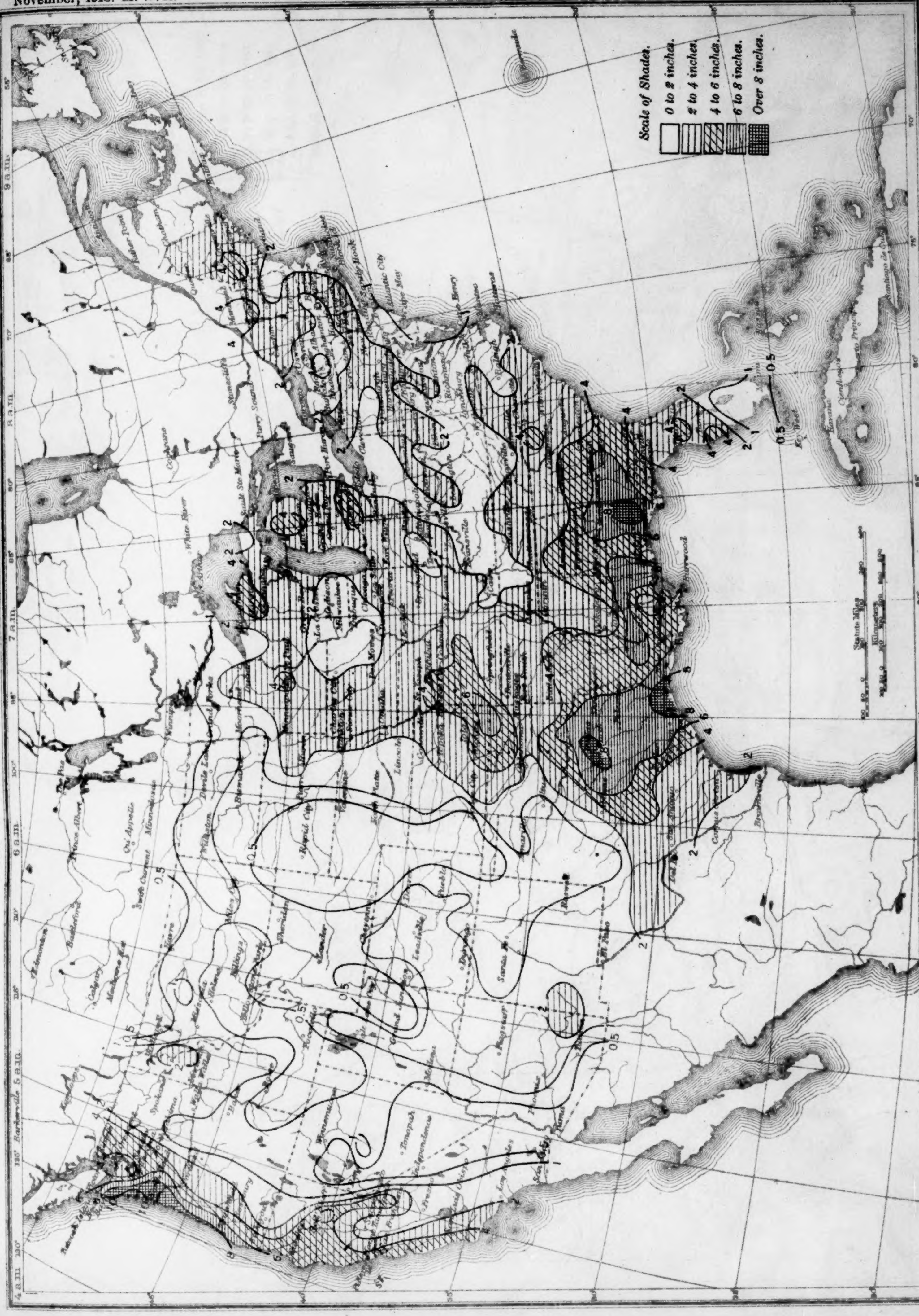

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, November, 1918.

Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, November, 1918.

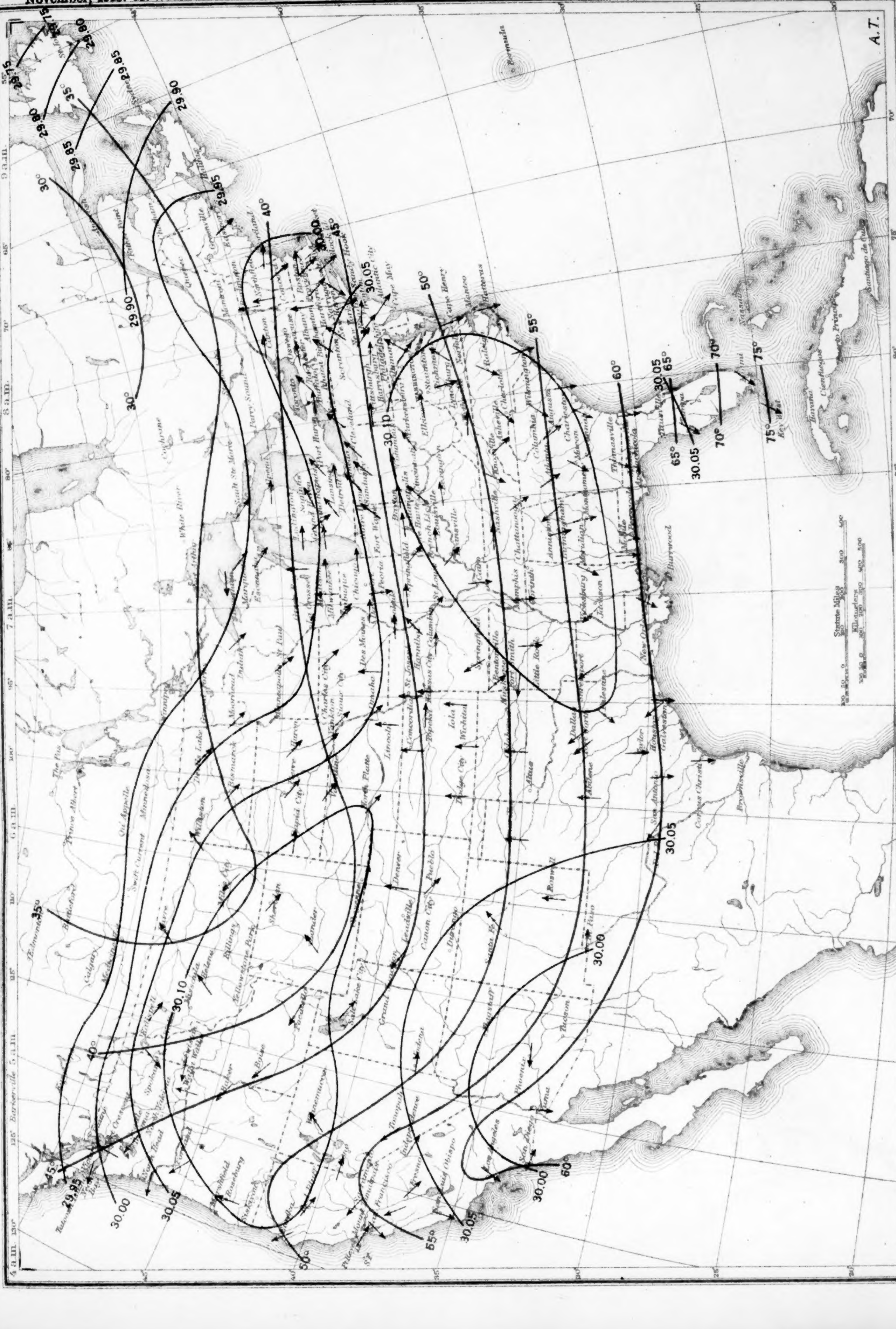

Chart VIII. Total Snowfall, Inches, November, 1918.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, November, 1917.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, November, 1917.
(Plotted by F. A. Young.)